# AN INVESTIGATION OF THE POTENTIAL UTILITY OF TECHNOLOGY ASSESSMENT TO THE FOOD INDUSTRY

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# Declaration

This thesis contains no material which has been accepted for a degree or diploma by the University or any other institution, except by way of background information and duly acknowledged in the thesis. To the best of my knowledge and belief, no material previously published or written by another person except where due acknowledgement is made in the text of the thesis.

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Julie Kimber

January 2011

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# Abstract

This PhD contributes to the discipline of food policy by introducing Technology Assessment (TA) as a potential tool for the food and biotechnology industries and food policy decision-makers. TA is an analysis tool used to consider the consequences of new technologies. This social research project investigated how TA can be used in the food industry and specifically how it can be used to assess the impacts of a new crop biotechnology on society.

The potential use of TA was evaluated using an emerging food biotechnology, long-chain omega-3 production in canola, which is being developed by the CSIRO Food Futures Flagship. This emerging biotechnology involves the production of genetically modified oil seed plants, designed to synthesise essential omega-3 long-chain polyunsaturated fatty acids (ω3 LC-PUFA). For the purpose of the thesis, these will be referred to as long-chain omega-3 oils. These oils are normally absorbed by humans by eating seafood, and are deficient in most people's diets. With declining global fish stocks, this dietary deficiency is likely to be exacerbated in the future. By making these nutrients available in commercial crops such as canola, it is anticipated that there will be improved health and environmental outcomes.

The qualitative social research methods used in this study included key informant interviews together with focus groups with a range of social groups who may be affected directly or indirectly by the omega-3 technology. The broader aim of the project is to increase awareness of the social issues present in the food industry and create information that can inform decision-makers at all levels of food industry.

The results identified several groups that would benefit directly from the technology, for example, the aquaculture and livestock industries, farmers that used conventional broadacre farming methods and the broader community in general as a result of improved health outcomes. Other groups that may be opposed or adversely affected include the fishing industry, organic farmers and environmental groups. There are some issues that warrant further attention if this technology is to be accepted into society. These revolve around the GM process used to produce long-chain omega-3 oils and the desire for labelling that would enable the Australian publics to make an informed choice about whether to purchase a particular product that contained the oil. The type of TA that could be used in the future and some of the potential problems that may be encountered if it was to be implemented into the food industry are discussed. The initiation and implementation of biotechnology policy is reviewed. There are some areas of concern regarding Australia's current GM regulatory framework, for example, compensation in the advent of inadvertent co-mixing. It is proposed that a TA vision assessment framework could create a shared vision for the future of food, which would inform policy-makers at all levels. TA has the potential to increase democratic principles by allowing a broader range of social groups to influence policy.

The thesis is significant in that it likely to be the first Australian application of technology assessment in the food industry.

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I am particularly grateful to CSIRO for providing me with a top-up scholarship and all the valuable financial and operational support and to the University of Tasmania for the co-funded scholarship.

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# Abbreviations

| | |
|---|---|
| ACCC | Australian Competition and Consumer Commission |
| ARC | Australian Research Council |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| CTA | Constructive Technology Assessment |
| DAFF | Department of Agriculture, Fisheries and Forestry (Australia) |
| DNA | Deoxyribonucleic Acid |
| FAO | Food and Agriculture Organisation |
| FSANZ | Food Standards Australia and New Zealand |
| GM | Genetically Modified |
| GMO | Genetically Modified Organism |
| GTCCC | Gene Technology Community Consultative Committee (Australia) |
| GTEC | Gene Technology Ethics Committee (Australia) |
| INRA | National Institute for Agricultural Research (France) |
| iTA | interactive Technology Assessment |
| MOSST | Ministry of State for Science and Technology (Canada) |
| NBAC | National Biotechnology Advisory Committee (Canada) |
| NGO | Non-Government Organisation |
| OGTR | Office of the Gene Technology Regulator |
| OTA | Office of Technology Assessment (US) |
| SCOT | Social Construction of Technology |
| SPS | Sanitary and Phytosanitary |
| TA | Technology Assessment |
| TASC | Technology Assessment in Social Context |
| TBT | Technical Barriers to Trade |
| TIAR | Tasmanian Institute of Agricultural Research |
| UTAS | University of Tasmania |
| WHO | World Health Organsiation |

# Preface

My family are from England and my parents were amongst the stream of £10 pommes that came out to Australia in the 1960s, so I was fortunate enough to be born in Melbourne. Our family returned to England (after a few trips to and from Australia) when I was about eight years old where I completed my schooling. At the age of 18, I commenced a Bachelor of Science degree in Agricultural Botany at Reading University. England was a good spot to hop over to Europe, so a friend and I managed to find a month's work at the French National Institute for Agricultural Research (INRA) in Renne. I worked in the entomology department which was great fun as I spent most of the day chasing caterpillars, collecting moths from the traps and learning how to mount butterflies. After that, we went inter-railing around Europe for a few weeks.

I always yearned to come back to Australia and in 1987 I came to Tasmania for a year's work experience working as a research assistant for Glaxo Australia conducting trials on poppies grown to produce alkaloids used in the pharmaceutical industry. It was hard settling back into English life and the third and final year of University made worse by the fact that I undertook my Honours thesis on seed technology in the same year. I flew back to Tasmania a week after my final exam and returned to the North West Coast of Tasmania where I soon commenced work with the Department of Primary Industries working on medicinal plants. I then worked as a Research Officer for a new company known as CIG Pyrethrum (now Botanical Resources Australia), established to grow a plant-based source of pyrethrin insecticide. I undertook various agronomic trials and started conducting some work to increase the germination of the little bag of seed that I had sitting on my filing cabinet. A few years later, I was the Seed Production Manager responsible for the production of the now high quality and quantities of seed for commercial plantings which replaced the traditional labour intensive, uneconomical vegetative system.

After leaving the company in 1997, starting a family and running tourist accommodation for five years, I did not want to re-embark on my previous work in the field of agriculture. I became reflective about the consequences of helping create a seed-based pyrethrum industry. I had created a technology that replaced the shed loads of workers who were employed on a seasonal basis to ‘split’ the plants into plantlets which were then planted by other teams on planters into rows. This row system was poor at suppressing weeds, so ‘spot-spraying’ and ‘hand-hoeing’ teams of people were employed to keep the weeds under control as the herbicide program was still being developed. As the company became the world’s second largest producer of pyrethrum after Africa, I wondered whether I had inadvertently replaced jobs in other developing countries that grew and harvested pyrethrum as a cash crop by hand. ‘Yikes’, I had transformed from a dedicated performance review driven scientist to become a scientist with a slightly guilty social conscience! I decided that I wanted to work with people rather than plants.

In 2003, I commenced a Bachelor of Arts which I completed in 2006, majoring in Sociology and Public Policy. I loved this degree and became passionate about certain topics such as gender and power, social policy and third world politics. These courses helped me to understand the world around me in a completely different light. I started looking for a job by talking to people I had worked with previously, and was fortunately directed by Professor Rob Clark (the then Director of the Tasmanian Institute of Agricultural Science, TIAR) to make an appointment with Professor Frank Vanclay the leader of the Rural Social Research Group in TIAR. Frank just happened to be advertising for a student to commence a PhD ‘Assessing the social consequences of new technologies’ and was looking for someone with a background in sociology, agricultural science or public policy. Bingo! I started in June 2006.

This PhD was a component of an overarching ARC Discovery project – Technology Assessment in Social Context (TASC). TASC was a collaborative project between Professor Frank Vanclay, Dr Wendy Russell previously at the University of Wollongong, and Dr Heather Aslin originally at the Bureau of Rural Sciences, then later at the Charles Darwin University. The aim of the TASC project was to develop a framework for technology assessment that would be effective in the Australian context and to devise a form of TA, which focused on the social context.

A case study was needed to pilot the emerging TASC framework, so I started to search for a food technology that was still in the research and development phase. This was difficult as the main aims, principles and conceptualisation of the TASC framework were still being developed. I remember asking Frank, ‘How can I test a framework that does not exist?’ to which he replied, ‘good question’! I was feeling increasingly uneasy about the PhD and moving further away from my dearly cherished scientific comfort zone where the methodology was established and I knew exactly how to approach and solve a ‘null hypothesis’! My work was made more uncomfortable during December 2006 as I incurred a severe back injury as a consequence of sitting for six months at an un-ergonomic (previous lab-bench) at the TIAR. It took me approximately 11 months to fully recover. The journey through the thesis, like many others, has had its ups and downs, however, I have met some fascinating and inspirational people. Undertaking the PhD has been an excellent way to combine my previous degrees and I have enjoyed being able to follow my curiosity into any discipline from science to philosophy and have learnt a great deal.

I am excited about the potential uses of technology assessment in the Australian food industry in the future as it offers a systematic process of anticipating and mitigating social, legal and ethical issues early in the innovation process. I have developed a passion for food and agricultural policy and hope to contribute to this field in the years to come.

# Chapter 1 – Introduction

This PhD contributes to the discipline of Food Policy by introducing the concept of technology assessment (TA) to the Australian food industry. According to the international journal *Food Policy*, on their aims and objectives page the discipline relates to the following issues surrounding food production:

- Food production, trade, marketing and consumption.
- Nutrition and health aspects of food systems.
- Food needs, entitlements, security and aid.
- Food safety and quality assurance.
- Technological and institutional innovation affecting food systems and access.

The primary research question is: how can TA be useful to the food industry? TA is used extensively throughout Europe to forecast and assess the potential social consequences of new technologies and is formally institutionalised. Throughout Australia there have only been a limited number of informal assessment exercises conducted by various agencies. This PhD was a component of an overarching ARC Discovery project – Technology Assessment in Social Context (TASC) – led by Prof Frank Vanclay through the Tasmanian Institute of Agricultural Research at the University of Tasmania in conjunction with Dr Wendy Russell (originally at the University of Wollongong) and Dr Heather Aslin (originally at the Bureau of Rural Sciences, now at Charles Darwin University). The aim of the TASC project was to develop a framework for technology assessment that would be effective in the Australian context and to devise a form of TA, which focused on the social context (Russell et al., 2010). The other aim was to establish a set of quality criteria for good TA after reviewing international best practice and discuss some of the options for institutionalising TA in Australia. The results of this research have been recently published in the paper: Russell, A.W., Vanclay, F., Salisbury, J. & Aslin. H. (in press) "Technology assessment in Australia: The case for a formal agency to improve advice to policy makers", *Policy Sciences* (letter of acceptance 12 July 2010). DOI 10.1007/s11077-010-9120-4

The potential of TA in the food industry was investigated by undertaking a case study on a new food technology being developed by the CSIRO Food Futures Flagship. The aim of the case study was to assess the potential social consequences of the omega-3 project, which involves the use of a genetic modification (GM) technology. The case study identified the social groups that may be affected by the technology and reported their views and issues that need addressing back to CSIRO. It is proposed that implementing a system of TA would improve upon the informal pre-assessment process that CSIRO currently undertakes. The types of TA and tools available that may be useful in other sectors of the food industry are discussed.

A review was conducted which looked at the complex array of food strategies and policies in existence across various Australian Government departments from agriculture through to public health. The introduction and implementation of Biotechnology in Australia and Canada have been compared, and the potential use of a ‘TA vision assessment process’ is proposed which may be useful to policy-makers in the future. Overall, as a field TA is still evolving and there is no one way of conducting or institutionalising it in the Australian food industry. However, it does have the potential to enhance democratic principles and citizenship by increasing the influence of a broader range of social groups in decision-making processes at all levels of food policy.

## What is technology and technology assessment?

There is no one definition or meaning to the word ‘technology’. The Technology Assessment in Social Context (TASC) project initiated in 2006 (Russell et al., 2010) takes a broad view of technology, which:

> comprises the products and processes of the application of human ingenuity for a particular purpose; and the knowledge, designs, standards, procedures and applications associated with that creation; and the social arrangements specifically associated with that creation (Russell et al. 2010, p112).

The emergence of technologies into a de-centralised marketplace involving many actors and agencies makes scientific governance problematic. Concerns were also expressed as to how to help society cope better with technology especially when it was introduced by free enterprise organisations (Porter, 1995). To address these concerns, the US Office of Technology Assessment (OTA) in 1974 was the first to form a system to inform legislators about matters arising from science and technology and make technology more socially acceptable. The functions of the early TA were to serve as an early warning system based upon a technocratic system of 'expert' scientific methods and modelling (Medford, 1973).

An OTA workshop report (1991, p4) considers that Technology Assessment:

> ultimately comprises a systems approach to the management of technology reaching beyond technology and industrial aspects into society and environmental domains. Initially, it deals with assessment of effects, consequences, and risks of a technology, but also is a forecasting function looking into the projection of opportunities and skill development as an input to strategic planning. In this respect, it also has a component both for the monitoring and for scrutinising information gathering. Ultimately, TA is a policy and consensus building process as well (UN/OTA, 1991).

TA has been developed and used extensively in Europe since these early technocratic approaches to types that involve a broader base of stakeholders, including the public in a process referred to as participatory TA (Hennen, 1999, Durant, 1999). Another type that increased the influence of social groups enabling a technology to be shaped from the onset by a process of co-creation is referred to as constructive TA (Rip et al., 1995, Genus and Coles, 2005, Genus, 2006). A number of different types of TA have and are still in the process of being developed overseas to address the needs of a specific audience, purpose and technology. The type of TA has to be tailored to suit the particular social and political context of a nation. To date TA has not been formally conducted or institutionalised in Australia. This aim of the case study conducted within the overarching TASC project is to assist the TASC researchers to help assess the potential of the proposed TASC framework. This new research is necessary to anticipate the potential benefits and possible barriers to implement a TA system in the unique Australian social and political context which is vastly different from that in European nations.

Although TA has been primarily used as a tool to forecast *probable* events, it is also useful to analyse *possible* futures using vision TA, which uses approaches based upon scenarios and utilises both science-based models and participatory techniques

(Roelofsen et al., 2008). There are previous cases where technologies have been developed for use in a different context that have caused unanticipated social impacts, which may have been identified and addressed if a system of TA had been applied. One technology was the development and introduction of new high yielding crop varieties into developing countries, which is discussed next.

## The green revolution: an example of how food technologies can transform social structures

Following World War Two, new agricultural and food technologies enabled food production to be industrialised, to produce large volumes of cheap homogenous products to feed Europe's hungry populous (Lang and Heasman, 2004). New crop varieties were developed that were higher yielding and more pest resistant, but often required higher fertilizer inputs and created dependence on fossil fuels. Natural resources were regarded as limitless and fuel was cheap. Environmental impacts were externalised under this 'productionist paradigm' of food production (Lang and Heasman, 2004).

These new food technologies were considered to have potential in the developing world. In the 1960s, new high yielding crop varieties, mostly grains bred by scientists in Western countries were introduced into developing countries such as India and Mexico. The aim of this was to alleviate hunger and famine and increase the health of populations. In principle, this sounded like a good, wholesome, charitable project that was intended to improve the lives of the poor. However, a lack of understanding of the social, cultural and political setting meant that the project failed in many respects due to a deepening of the gap between the rich and the poor.

While widespread benefits such as 'solving third world hunger' were extolled, many feared the Green Revolution of the 1970s served those with power and wealth and not the economically disadvantaged as was claimed (Griffin, 1974, Shiva, 1991). The situation in India documented by Crow and Thrope (1988) is summarised in the following paragraphs. In 1947 the agrarian social structure was dominated by a ‘landlord class’ that leased land to peasant farmers at rent levels that were high as a proportion of the income of those farmers. This was exacerbated by compounding interest rates, which often led to a situation of ‘debt bondage’. This meant that the debtor would have to work for the landlord on additional land, often leading to the neglect of their own farm. The peasantry were therefore unable to accumulate wealth and had to work to survive, unlike some of the already advantaged ‘richer’ or ‘middle’ peasants who also employed labour. There was also a more disadvantaged class of ‘landless labourers’ in India that made up 15 percent of agricultural families in 1951. It was therefore difficult for these disadvantaged groups to escape their situation and improve their livelihoods. Under this system, women were further disempowered as land was only allowed to be owned by men. This structure constrained the development and innovation of new technology and restricted agricultural productivity.

In order to increase productivity and stimulate technological advancement, an ambitious land reform program was introduced in the early 1950s. This advocated the abolition of the landlord class and the adoption of a ‘land-to-the-tiller’ principle that aimed to provide fair and secure rent and tenure to most peasant farmers. There were also constraints placed on the amount of land a peasant could occupy, to ensure that as many peasants as possible had access to land. The largest landlords that arose after British occupation were therefore hardest hit by these reforms, as they were predominantly absent from the land, which they did not cultivate.

The winners were the medium to small landlords that were resident on the land that they sometimes cultivated; who then became capitalist farmers. This group, although unable to abolish fair and secure tenancy, often took verbal rather than written forms of tenancy allowing them to evade the law. They were able to develop their own interests extending the amount of irrigated land and commercialising further. By the mid 1960s, there was a notable shift in power relations whereby the power of the landlord classes reduced and the political and economic strength of the rich peasants increased. This group were the biggest winner who became the dominant class in many areas as established proprietors able to use legislation to secure a sizable proportion of the tenanted land. Groups who did not gain any benefit at all from the reforms were poor peasants, landless labourers and other villagers. Productivity was still low with agriculture growing at a rate of just three percent annually, which despite being faster than the previous fifteen years was insufficient to feed the growing population. Only some mechanisation and fertilizer factories had been developed and a few improved seeds were available. The government also attempted to stimulate productivity by investing in large scale irrigation in some areas such as Punjab, but many other states missed out. A crisis emerged as agriculture could not sustain the population resulting in the necessity to import large quantities of grain predominantly from the US food aid program.

An agreement was made for America to provide grain for the period 1962-65, however when war erupted with Pakistan in 1965 after only half of the quota had been fulfilled, aid shipments stopped. India remained unable to produce enough food for the populous entered into an agreement with the Americans for a period of seven years. This agreement meant that the Indian government lost control over prices and distribution of fertilizer produced by private firms, and could no longer maintain their 51 percent joint ownership of ventures in the fertiliser field. Also, those that were owned by American private firms were allowed more latitude and trading with North Vietnam ceased.

In 1964 a new Minister of Food and Agriculture was appointed announcing a formula and plan to reduce dependence upon the American supply of grain and deliver self-sufficiency. This was termed the ‘Green revolution strategy’ and because of its paramount importance, its implementation was well underway by 1967. Its aim was to increase Indian agriculture growth to five percent per annum. The strategy focused on the application of inputs rather than implementing social change. The primary inputs were comprised of mechanical and biochemical innovations. Mechanical innovations included seed drills, tractors and mechanical pumps for irrigation. Biochemical inputs encompassed chemical fertilizers, pesticides and the use of high-yielding F1 hybrid crop varieties. F1 hybrids are bred from inbred parent lines which when crossed produce progeny with ‘hybrid vigour’ that gives them their superior traits. Unfortunately seed from such plants if collected and sown the following year (F2 progeny) do not possess hybrid vigour and the same desirable traits. This means that seed has to be bought each season from Taiwan where improved rice varieties had been developed and Mexico for improved wheat. Some new varieties of maize, sorghum and millet were also to be used that were developed in Indian research stations during the late 1950s. These 'coarse grains' are predominantly grown in rain-fed drought prone areas, however such areas were not seen as a priority in the Green Revolution strategy and continued to produce poor yields overall. Legumes were also left out of the strategy which actually increased the rate of decline in pulse production. Rice and wheat are considered superior food grains that are consumed primarily by the more affluent. The poor would only gain access to such foods if the price was low enough for them to afford, or if their income was increased.

The failure of the research stations developing the new varieties to consider the ecological, social, political and economic factors made the strategy fundamentally flawed. In theory, the biochemical inputs could be more beneficial as they can be applied by the tenants or landless labourers thus increasing employment. Mechanical innovations on the other hand reduce labour needs and the vast capital expenditure required to purchase equipment restrict its use to wealthier people who possessed larger landholdings where the expense could be justified. At the time only 17 percent of India's arable land was irrigated in a few states meaning that more than 80 percent of the arable land was excluded from the green revolution. Biochemical inputs were necessary to achieve the improved yields creating dependence upon the manufacturers of the products. This restricted the benefits to the minority who could afford them rather than the poor majority. Some varieties such as the Mexican dwarf wheat varieties were successfully grown using cultivation practices that were conducive to Indian farmers, especially in states located in the North West. The government initiated a breeding program that went on to develop even better wheat varieties. The rice varieties were less successful as they were prone to insect pests and growing conditions in most states, thus only benefiting a few farmers in particular areas.

Overall, this case demonstrates how the implementation of new political strategies and technologies can create a new dominant social class, in this case the capitalist farmers. The development of new varieties that required high fertilizer and pesticide inputs also carries with it the potential for environmental damage and may pose a threat to the health of workers applying such inputs without protective clothing. The livelihoods of the poorest members of the population were not enhanced as they were unable to increase their economic and political power and access new well-intended technologies. This widened the gap between the rich and poor. New technologies have to be bought in order for the technology developers to recoup their costs, thus it seems that money nearly always goes to money. Scientists should be mindful and reflective about whether the technologies they develop may actually impact upon others in different complex social and political settings. The unequal balance of power between Western and developing countries can also manifest itself as situations arise and should always be kept in mind (Crow and Thorpe, 1988).

## Genetically Modified Organisms (GMO)

The full definition of a GMO appears in section 10 of the *Gene Technology Act (2000)* and can be found on the Office of Gene Technology Regulator website. In essence, a GMO means:

> a) an organism that has been modified by gene technology; or
> b) an organism that has inherited particular traits from an organism (the initial organism), being traits that occurred in the initial organism because of gene technology.

There are different categories of GM crops referred to as first, second and third generation crops. First generation crops have traits such as herbicide tolerance and insect resistance, which allegedly primarily benefits farmers and potentially the environment by reducing the quantity of pesticides that are required throughout the growing period. For example, Bt cotton which was genetically modified to resist insect attack and express herbicide tolerance was introduced into Australia in 1996 and in 2005 constituted approximately 90 percent of the total national cotton crop (Tribe and Kalla, 2005).

Second generation crops are those that are developed to enhance the quality of food or feeds and provide benefits for the producer and the public. They include a range of crops designed to produce biochemicals that will benefit the broader community, as they produce health promoting substances or enhance the flavour of foods. For example, the CSIRO Food Futures National Research Flagship is developing a second generation crop technology to address a range of health problems such as cardio-vascular disease, arthritis, asthma and other disorders by engineering oilseed plants to produce long-chain omega-3 oils (Nichols, 2004, Robert et al., 2005, Ruxton, 2007). This is the case study that is examined more closely later in this thesis.

Third generation traits allow the plant to be used as a ‘factory’ to produce pharmaceuticals or industrial products that are synthesised in the plant, such as vaccines (Castle et al., 2007). Plants that are developed to produce pharmaceuticals are referred to as pharm factories. A full review of which GM crops are being developed in Australia can be found in reports published by the Australian Government Bureau of Rural Sciences (Glover et al., 2005, Glover et al., 2008).

## Food governance

The governance of agricultural trade and food safety regulation can be traced back to the antiquity, and by the thirteenth century European and English guilds concerned with food safety began to regulate it to protect traders and consumers from risks and unsafe commercial practice (Carruth, 2006). Such regulation was used as a source of monopoly power by the guild for strategic advantage. By the nineteenth century awareness of the dangers of chemical contamination were mounting and as a result the regulation of food purity and safety based on scientific testing led to the discipline of food science (Carruth, 2006). Towards the end of the nineteenth century, new technologies for preserving food products for the growing international processing food industry were introduced and continued to expand due to increasing consumer demands. In the early post-Second World War period, the concerns expressed by both the government and public escalated due to the increased dependency on preserved and processed foods not encountered prior to this period. The twentieth and twenty-first centuries witnessed the emergence of food safety issues related to microbial pathogens, pesticide and chemical contamination, the emergence of genetically modified food and the increased volume and complexity of international food trade system. This required the design and implementation of new scientific and policy frameworks which were highlighted by outbreaks such as Mad Cow disease and fears of avian flu (Carruth, 2006).

The industrialisation and globalisation of food has created many challenges for Australian food regulators and is undertaken across three different levels, international, federal, and state. Each level has numerous agencies and policies to control the production, processing, transport, export and marketing, retailing and food service outlets. This makes for a very complex array of regulations that can be a source of frustration to some sectors of the food industry whilst offering a satisfactory level of food safety. A few of the agencies involved and their responsibilities are outlined below.

At the international level, as a result of the introduction of the US led Bretton Woods system, the World Trade Organisation (WTO) was formed in 1995 to facilitate trade liberalisation, settle disputes, sponsor and promote multilateral trade talks (Payne, 2005). It regulates the trade of agricultural products made using biotechnology to protect human, plant, and animal health, and the environment. GMOs are subject to the Sanitary and Phytosanitary (SPS) Agreement. The SPS Agreement addresses risks from contaminants, toxins, additives and disease-causing organisms, however, it is not clear which category is applicable for the assessment of GMO foods. The SPS Agreement ensures that the appropriate international standards are used for a product. The primary food standards body is the Codex Alimentarius Commission ('Codex'). Codex was formed in 1962 under the joint sponsorship of the World Health Organisation (WHO) and the Food and Agriculture Organisation (FAO). Its function is to develop consistency in food standards in the global trade environment. In order to protect health and safety and to ensure that food trade is undertaken in a fair way, standards for pesticide levels, food labels and hygiene practice are established and monitored. If products are not a SPS risk, they can still raise issues in other areas.

Countries often have different requirements when it comes to technical issues related to, for example, GM food products. If it does not concern intellectual property rights, then issues, for example labelling, fall under the Technical Barriers to Trade (TBT) Agreement. Another important piece of international legislation is the United Nations

Cartagena Protocol on Biosafety, which was signed by 156 countries in May 2000. This document regulated, for example, the transboundary movement, transit, handling and use of all living modified organisms that may be detrimental to human health and biodiversity (Xue and Tisdell, 2002).

In addition to international regulation, there are various Australian federal agencies that are responsible for specific areas of regulation. The agency responsible for gene technology is the Office of The Gene Technology Regulator (OGTR) which was established under the *Gene Technology Act 2000*. This Act requires the OGTR to prepare reports for the Minister of Health and Ageing regarding the issuing of licences for the release of genetically modified organisms. In addition, Food Standards Australia and New Zealand (FSANZ), a federal agency located in the Department of Health and Ageing, regulates the food industry and is responsible for the establishment and maintenance of food safety standards. FSANZ is composed of various committees and councils. The Ministerial Council, for example, is responsible for the development of domestic food regulatory policy and policy guidelines for setting domestic food standards. It also promotes the harmonisation of food standards between states and territories, and between domestic and export standards according to international food standards set by Codex. The Ministerial Council also provides a general oversight of the implementation of domestic food regulation and standards and promotes consistency in the compliance with, and enforcement of food standards.

There are other non-government organisations such as the Australian Food and Grocery Council, which is a national organisation representing Australia's processed food, beverage and grocery products industry. It seeks to help create a business environment that encourages the food and grocery industry to grow and remain profitable. Food regulation is also the responsibility of the states and local governments who have to ensure that requirements relating to mandatory food safety are followed. This includes, for example, routine inspections of food processing, retail and food service outlets.

## The case study of the CSIRO Food Futures Flagships omega-3 project

As indicated earlier, this PhD was a component of an overarching ARC Discovery project called ‘Technology Assessment in Social Context’ (TASC). The aim of the TASC project was to develop a framework for technology assessment that would be effective in the Australian context and to devise a form of TA, which focused on the social context (Russell et al., 2010). A case study was established to pilot the emerging TASC framework. The proposed TASC framework developed by Russell, Vanclay and Aslin consists of a stepped process of:

- Scouting – identifying emerging technological developments in the pipeline.
- Screening – selecting and prioritising technologies for assessment based upon criteria such as its potential to have a high social impact (magnitude & distribution) where outcomes may be uncertain, or where there is likely to be community concern.
- Scoping – conducting a preliminary assessment to frame the topic, its purpose, the methods that should be used, stakeholders & resources needed.
- Assessment – of the potential social consequences associated to a particular technology.
- Communication and participation – Facilitating multi-way communication between stakeholders.
- Evaluation – reflection on the process, methods, content and outcomes (ongoing learning).

For the purpose of the case study, a number of new emerging technologies were identified in the scouting stage of the TA. These included, for example, the use of nanotechnology in the food industry, the use of genetically modified poppies or the introduction of koi herpes virus for the control of carp. The screening process analysed the potential impacts that may occur if each particular technology were to reach commercialisation. The criteria examined included the size of the population that may be impacted and the magnitude of impacts on particular social groups or the environment. The confidentiality of information was also assessed as this may limit the research process. The technology would ideally be one in the initial stages of development and may be seen by some as highly controversial. The CSIRO Food Futures Flagship omega-3 project was chosen as a case study as this was still in the research and development phase and was likely to have widespread benefits to society. Ideally, TA should be initiated very early in the development of the project to maximise the chances of it being shaped by society to maximise the chances of it being accepted prior to commercialisation. At the commencement of the project, the CSIRO project was approximately 5 years into the research making it difficult to change the trajectory of the project, however, it was seen that there may be more adverse social consequences if this project failed to be commercialised. The CSIRO were approached to see if they were interested in allowing the omega-3 project to be the subject of the case study. They were very keen for this to occur and have worked closely with the TASC researchers for the duration of the study.

Long-chain fatty acids can be defined as containing 20 or more carbon atoms in the molecule (Nichols, 2004). The main aim of the CSIRO omega-3 project was to produce a sustainable land plant-based source of omega-3 long-chain polyunsaturated fatty acids (ω3 LC-PUFA) to supplement current fish oil sources (Nichols, 2004, Nichols, 2007). These are also referred to as long-chain omega-3 oils, which will be the term generally used in the thesis. Currently fish oil used in aquaculture feeds and for human consumption is obtained by harvesting wild fish stocks which are in decline due to overfishing and other environmental pressures (Pauly et al., 2005). This project would reduce the pressure on wild fish stocks by developing a sustainable source of long-chain omega-3 oils.

There is an increasing body of evidence that consuming long-chain omega-3 oils improves the health and well-being of human and animal populations (Ruxton, 2007). The product from the omega-3 project would increase the supply of long-chain omega-3 oils available for consumption and/or utilisation. The aquaculture industry is by far the largest user of long-chain omega-3 oils, which are incorporated into feeds (Bimbo, 2007). At present this nutrient is mainly obtained by crushing low-value fish and by-products that are deemed less desirable on the market due to their small size or species (i.e. ‘trash fish’ and bycatch). Besides improving health, this project aims to help the environment by reducing the pressure on fish stocks by producing a land plant-based source of these nutrients. The TA for the case study of omega-3 was undertaken by conducting 30 interviews and 6 focus groups with a range of stakeholders.

## Thesis structure and aims

The thesis is structured as follows: Chapter 2 reviews the potential social issues pertaining to the use of GM technology in Australia which vary according to the cultural meanings that are associated with the production, processing and consumption of food and the way that risk is conceptualised by different social groups. The question as to whether GM crops pose a different risk than those bred using conventional plant breeding methods to the environment is examined, and the potential legal ramifications of inadvertent co-mixing between GM and GM free crops is discussed. This chapter also critically reviews some of the issues associated with safety testing protocols for GM foods and questions if it is necessary to introduce post-market surveillance, and whether the current labelling system is sufficient.

Chapter 3 examines how TA processes may be used to assist food technology policy-making in the future. Some of the approaches used to understand the meanings and reasons why technology can provoke feelings of fear or wonder are outlined. The background and development of different types of TA, their application and the tools available are explained. The way biotechnology policy was introduced into Australia is compared to how this policy was implemented in Canada. It is then proposed that the current fragmented nature and duplication of strategic agricultural and food policy documents produced by various government departments may be improved if a system of TA vision assessment could help create a shared vision for future food policy in Australia.

Chapter 4 describes the background and aims of the CSIRO omega-3 project and reviews the scientific literature surrounding omega-3 fatty acids. The methodology and results of the case study reflecting the views about the omega-3 project gathered during key informant interviews and focus groups are presented and discussed. The case study forms a central part of the overarching TASC project in that it tests the proposed framework and provides key information about how it can be improved in the future. There are limitations to this due to the short time of a PhD project and the availability of human and other resources. A full TA requires a team of multi-disciplined personnel engaged over a period of up to ten years depending on the technology being assessed and according to the need for ongoing monitoring and evaluation. This was beyond the scope of this particular case study so after careful consideration, it was decided to concentrate on one case study only.

Chapter 5 addresses the research question ‘Can TA be useful to the Australian food industry?’ In Chapter 4 the responses of the case study participants were presented that reflected views about the CSIRO omega-3 project. In addition, key informant interviewees were asked what their thoughts were about the potential usefulness of TA in the food industry. The responses are provided and a discussion follows about the experiences and issues encountered by other agencies that have experimented with TA. This is followed by a discussion about the types of TA and which sectors in the Australian food industry may find it useful.

Chapter 6 concludes the findings of the case study and provides recommendations for CSIRO. Suggestions for the food industry and areas for further research are also discussed.

# Chapter 2 – What are the potential social issues pertaining to genetically modified organisms (GMOs) in Australia?

The development and introduction of genetically modified (GM) crops has a chequered history in some countries in terms of public acceptance (Marris et al., 2001), and is one of the most significant and contentious societal debates (Cocklin et al., 2008). Issues such as neglect of public acceptance has, according to some authors, led to the current political debate related to food biotechnology (Zechendorf, 2004). This chapter provides a backdrop to the case study of the CSIRO Omega-3 project by reviewing the literature pertaining to the social issues and controversy surrounding the introduction and utilisation of GM technology. The issues outlined have provided the researchers with a broad knowledge base for the conduct of the case study.

Canada and the United States have embraced GMOs, with the USA growing than 47 million hectares of GM crops annually. The second largest producer of GM crops is Argentina, where 16 million hectares were grown in 2004 (James, 2004). The European Union has not been generally accepting of GM and between 1998 and 2004 a moratorium on the approval of GM products was in place (Lieberman and Gray, 2006). In 1999, public debate about the use of GM food led to the emergence of the metaphor ‘Frankenfoods’ (Thelwall and Price, 2006). This term was a juxtaposition device to suggest the adverse consequences of scientists reconstructing and modifying life forms. NGOs like Greenpeace used the term in many of their anti-GM protests, referring to GE fish as ‘Frankenfish’ (Greenpeace, 2007) (see Figure 2.1).


Figure 2.1: Illustration depicting concern about GM food Source: http://www.newresilient.com/2009/04/20/tell-me-whats-in-my-food-gmos-and-stark-contrasts-in-world-food-policy/

Australia faces many challenges related to the production of food. These include climate change, water shortages and land degradation. To address these problems, GM crops are being developed by scientists working in universities, CSIRO, state government research units and in the private sector. It is believed that by adding or enhancing desirable traits of a crop, GM technology has the potential to increase food production, reduce environmental impacts and provide health benefits (Morell, 2008). Within Australian society, GM crops have been a contentious issue which has been debated over the past decade or so (Cocklin et al., 2008). Some have supported the technology, e.g. the Victorian Farmers Federation and the biotechnology companies. Others have been opposed to its use and a number of lobby groups have emerged: e.g. Genethics (www.geneethics.org) and the Network of Concerned Farmers (www.non-gm-farmers.com). Whilst GM technology may be useful in certain situations, there are potential social issues arising from its use that need attention. If the social, ethical and legal issues pertaining to an emerging technology are understood, the chances of it being successfully embedded into society may increase. Identifying potential issues may provide an opportunity to mitigate any undesirable consequences that may affect particular social groups. This can include the development of protocols for monitoring, new regulations, reviewing and reallocation of the responsibilities of existing government agencies. The potential social issues that may affect the use GMOs in Australia are discussed in this chapter, which is divided into two sections:-

1) The social issues pertaining to GM technology

   What are some of the social meanings of food?

   How is risk conceptualised by different social groups?

   Is GM technology accepted by the Australian publics?

   What are some of the pros and cons of different food production methods? Do GM crops pose a greater risk to the environment than non-GM cultivars?

   What are the issues associated with the management of GM and non-GM crops in Australia?

2) The potential social issues pertaining to genetically modified foods?

   How much testing is required for GM or any other foods?

   Is post-market surveillance needed?

   Should GM foods be labelled?

## The social issues pertaining to GM technology

### What are some of the social meanings of food?

Australia, today, is a multi-cultural society composed of immigrants from all corners of the world. Each culture brings with it a diverse range of views about the way food should be produced, processed and consumed. The 'sociological imagination' is a useful framework to understand culture. Building on Evan Willis (1995), this concept was utilised by Germov and Williams (1999) as a way of thinking about food, the way we eat and why we like or dislike certain foods. They present a checklist of four interrelated components: historical, cultural, structural and critical factors. Historical factors refer to the influence of traditional ways that are passed down through generations. Cultural values refer to what foods are regarded as being edible, acceptable or taboo. Structural factors may refer to the nature of the economy or, for example, how the production, distribution and consumption of food is structured by the prevailing food system and regulatory arrangements. Different social structures constrain how, and to what extent individuals can operate. The term critical in this context relates to being reflexive or sceptical about a certain social setting or phenomenon. A critique involves asking questions such as 'how do you know?' and 'are there other possibilities?' Critical factors such as the method of agricultural production may affect external impacts, for example, on the environment that may lead to the development and change to alternative methods (Germov and Williams, 1999). Although it is often difficult to differentiate cultural from historical events which may be at times reinforced by particular structural factors, the 'sociological imagination' forms a useful template for sociological analysis (Willis, 1995).

Food forms a central role in our social relationships and patterns with each other, and our association with plants, animals and the environment from the local to global scale. Food is central to our sense of identity and our sense of place, and is instrumental in distinguishing different cultures and strengthening group identity (Lupton, 1996). The so-called Mediterranean diet, which comprises olive oil, fish, fruits, nuts, grains, beans and a moderate amount of alcohol, forms the basis of the traditional cuisine of countries such as Greece, Italy, Portugal, Cyprus, Spain and Turkey (Pérez-López et al., 2009).

Hunger is not just a biological phenomenon because of the array of cultural dimensions that determine what and when we eat, and the social context in which consumption occurs. The relationship between the body's physiological needs and the emotions that arise is complex. Lupton (1996) describes the different types of hunger that relate to the concept of appetite. She says that "appetite is an emotionally flavoured hunger" that differs from the feeling experienced merely from an empty stomach, especially when a favourite food is being cooked (Lupton, 1996, p33). The types of food that are acceptable or taboo are also embedded in cultural norms and values. The Chinese, for example, have a very pragmatic approach to food and will consume almost all animal parts such as chicken feet and pigs' trotters that would be repugnant to other cultures, just as strong cheese is repugnant to some Chinese (Lupton, 1996).

The production and trade of processed food has had a profound impact on societies across the world. New food processing technologies and the development of mandatory standards have led to improvements in food safety. In some cases, preservatives, stabilisers and a host of other compounds are added. The volume of processed foods traded across the globe increased rapidly during the 1970s and 1980s, and by the early 2000s supermarkets had spread into the middle-class neighbourhoods of many countries (Regmi and Gehlhar, 2005). This increased the volume of new foods entering into societies across the world providing alternatives to traditional, locally grown foods. Processed foods widened the gap between food production and consumption. The slow food movement attempts to reconnect with the cultural meaning behind food production, preparation and eating (http:/www.slowfood.com). This movement originated in Italy and has spread around the world. Its ideology reflects the desire to revert to growing, processing and eating food in their cultural or family group, thus reconnecting them to the means of production. The rapid spread of fast-food restaurants has evoked mixed reactions in various countries for a variety of reasons. George Ritzer (1993) expanded on Max Weber's concept of rationalisation by using the metaphor 'McDonaldisation'. This he used to describe the process by which the fast-food restaurant McDonalds, with its assembly line system of production, have dominated more and more parts of American society and have introduced the American culture into other parts of the world (Ritzer, 1993).

The spread of fast food restaurants in some countries has caused adverse reactions from the public based upon religious beliefs. In India, for example, there have been protests against McDonalds because of concerns that their products contained ingredients that are taboo. One report published in an Indian newspaper*, The Hindu* newspaper stated that Hindus avoid eating beef and pork, and it was feared that these were being used in the products (http://www.hinduonnet.com/2001/05/06/index.htm). According to Ohnuki-Tierney (1997), the impact of McDonalds in Japan has changed many traditional cultural manners and etiquette. For example, rice, which is of paramount importance in the Japanese diet, is traditionally served, usually in a wooden bowl, to a table occupied by various community members, and eaten using chopsticks. It is dished out using a ladle, usually by the female head of the household. In contrast, hamburgers are eaten by each individual often on their own, using what is viewed as 'unclean hands'. This can be overcome by keeping the burger in the wrapper to avoid contact with the hands. Ohnuki-Tierney (1997) states that many Japanese aspire to the American culture and ideologies that are portrayed to them. Despite the traditional strong sense of nationalism, the Japanese see America as a model to emulate. This is because for them America represents an image of a classless society, in contrast to their own strict hierarchical Japanese society where conformity is expected (Ohnuki-Tierney, 1997). Fast food outlets such as McDonalds offer an unhealthy alternative to traditional healthy foods that are locally available. McDonalds is just one example and other fast food restaurants have attracted similar opposition.

The social meaning of food needs to be considered by food technology developers as it reflects the norms and values associated with a culture.

## How is risk conceptualised by different social groups?

Food produced using GM techniques, as mentioned earlier, has evoked mixed responses from different social groups for many reasons which have been studied extensively. One concern is that genetic engineering is conflicting with the concept of ‘nature’ and raising associated moral issues (Kaebnick, 2007). A review by Costa-Font et al. (2008) outlines some of the main determinants that underpin people’s attitudes towards GM foods, which vary considerably between different countries. An explanatory process of GM food acceptance is summarised in the following chart (Figure 2.2), however, the authors emphasise the need for more research to understand the behavioural mechanisms that drive consumer behaviour (Costa-Font et al., 2008). Americans are less likely to be aware that they are purchasing GM food products due to voluntary labelling and may be more accepting than, for example, Europeans because they generally have a greater level of trust in government food safety policies. Europeans are more informed about the presence of GM products as a result of mandatory labelling, however, for some seeking GM-free products, mandatory labelling is inadequate as threshold levels are irrelevant. The willingness to purchase GM foods can also be influenced by different perceptions of risk and benefit. Some studies have shown that the benefits of products derived from first generation GM crops, with traits for herbicide tolerance and pest resistance, are not sufficient to outweigh the potential risks.

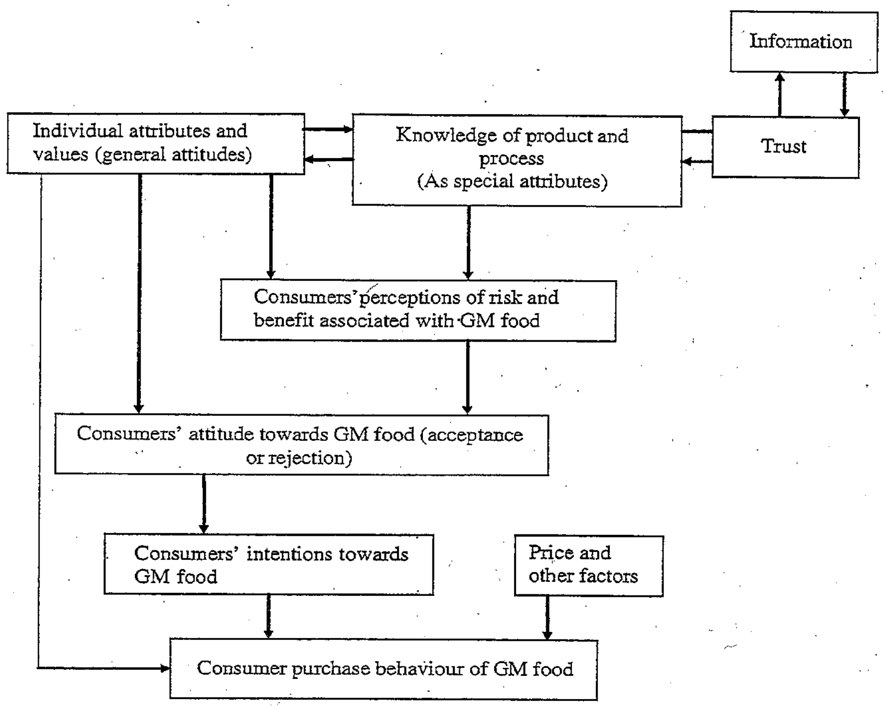


Figure 2.2: An explanatory process of GM food acceptance
Source: Costa-Font et al. 2008.

Risk assessment can be based upon a technical definition in which the magnitude of the risk is directly related to the probability of a hazard occurring and the likely magnitude of the impact. The technical concept of risk can be perplexing to scientific assessors as even risk events that may result in minor physical consequences can elicit strong public concern (Kasperson et al., 1988). Public perceptions are based upon intuitive biases, economic interests and may reflect cultural values. In Europe some of the controversy over GM crops is centred around the potential risk to the environment. Conflicts about risk can be based upon varying conceptualisations of risk as understood by different social groups such as scientists, regulators and different segments of the general public (Hauge Madsen and Sandoe, 2005). Savadori et al. (2004) examined the differences in risk perceptions between experts and non-experts with the latter perceiving biotechnology applications as more risky. Both groups considered food-related applications rather than those designed for medical use. Public estimates of the risks associated with food biotechnology have been found to be based upon potential harm, potential benefits, science knowledge and familiarity, whereas experts' estimates are predicted only by narrower parameters of harm and benefit (Savadori et al., 2004). The implications of risk research have led to increased attempts to educate people by presenting quantitative risk estimates for a hazard, for example, the risk per hour of exposure or reduction in life expectancy. The provision of quantitative information fails to consider many important factors that go beyond 'rationale' making it essential for each side to communicate in a structured two-way process where both sides show respect for the opinions of each other (Savadori et al., 2004).

Science is too often claimed to be an 'objective' basis for policy and is used by regulators as a hegemonic source of expert advice that is supposedly value free (Raybould, 2007). Scientists usually assess risk according to a null hypothesis of no difference between GM and non-GM crops that often results in detailed descriptions of ecological systems. Although this kind of assessment complies with the values of scientific communities as an objective technical report is produced that can be peer reviewed, however, it may not be meaningful to other social groups.

There are also problems that hinder the communication and learning between scientists and policy-makers due to the way in which scientists report their findings – ways that are often only decipherable by other scientists. Research into the environmental risks of GM crops has been said to increase controversy about the potential impacts and has not assisted decision-makers due to the misalignment between the nature of the research, and the problem definition made in relation to policy objectives (Raybould, 2007). Raybould (2007) suggests that assessments need to take into account non-scientific criteria that may not necessarily be measurable. In other words, they need to include subjective as well as objective information, so that the values of decision-makers and publics are taken into account. The problem definition and the assessment endpoint should reflect values, such as something they think is worthy of protection, for example, a particular species of bird. Scientists therefore have to create information that is more comprehensible to a wider range of social groups rather than only to the scientific community (Raybould, 2007).

The way in which organisations and the media frame GM products as being either 'radically new' or 'merely novel' influences the public's perception about the risks of GM foods. Radical technology refers to new technology that may require changes to industrial and market structures, and potentially to regulatory frameworks, as uncertainty is perceived as being a higher risk than with incremental technologies. Cranor (2003) points out that risks are more acceptable if they are tangible and easily detectable and can therefore be avoided if desired. Invisible risks which are difficult to detect and avoid, such as exposure to chemical substances, are less acceptable. More acceptable risks are ones which offer the user benefits, even if there is potential for an adverse effect such as with prescription drugs. According to Cranor (2003), GM plants represent an invisible risk which is difficult to detect and avoid, and resembles the risks associated with chemical exposure. Labelling is a way of reducing the invisibility and detectability of the perceived risk from GM foods, and provides information about the potential benefits of consuming such products (Cranor, 2003).

## Is GM technology accepted by the Australian publics?

To encourage public participation, in 1999 the Australian Consumers Association (ACA, now called CHOICE) used a framework taken from participatory technology assessment to establish the first Australian consensus conference (Mohr, 2002). A consensus conference can be a useful way to explore policy issues and to evaluate the levels of communication between government, industry and the Australian publics. One lesson learnt was that careful consideration needs to be given if the consensus conference model is to be used in a new social context to ensure that the organisers and participants are clear about what can and cannot be achieved (Mohr, 2002). Anticipatory socialisation in the lead up to the conference may have clarified the process and expected outcomes. The event undertaken in Canberra was criticised because the report on the process used was lacking in details, such as the method used to select the lay panel (Mohr, 2002). The lay panel provided an optimistic view of the consensus process the and some of the recommendations included the desire for the overriding principle of any gene technology legislation to encompass the environment and the mental and physical health of individuals (Davison and Schibeci, 2000). Also, mentioned was that all GM foods should be comprehensively labelled and that an ethicist is involved in decision-making regarding GMO policies.

Dietrich and Schibeci (2003) reviewed surveys conducted on GM foods in Australia since 1995. They were critical of the way that 'the public' were not treated as active citizens in an array of relationships that extend from the laboratory to farms and numerous other social communities. Instead, the public are often excluded from participating in the processes of government and industrial innovation, which has contributed towards the polarised attitudes towards GM foods like we have seen in the UK. They also suggest that Australia needs to develop a process that encompasses deliberative and inclusionary processes (DIPs) for the many 'publics', by using consensus conferences and citizens juries (Dietrich and Schibeci, 2003). Attempts have been made to systematically characterise the scientific literature relating to the public perception of genomics. An analysis of published articles by Pin and Gutteling (2009) showed that the research focus has changed over time since the mid 1990s from ethics to perceived risks and benefits and that public pressure has had some effect on the scientific research agenda (Pin and Gutteling, 2009). The results indicated a clear dividing line between authors publishing on either red (medical applications) or green (food and agricultural applications) of genomics.

Quantitative studies have been conducted to ascertain the acceptance by to Australians of second generation GM products that offer a direct health benefit, for example, long-chain omega-3 oils (Patch et al. 2005a, Cox et al. 2005a, Cox et al. 2005b). It is reported that a some people were prepared to consume long-chain omega-3 oils derived from a GM process especially when it was incorporated into fish food (Cox et al., 2007). Consumer research predominantly based upon results from surveys has been undertaken to ascertain perceptions of risk to biotechnology in Australia (Cormick, 2003) and to endeavour to explain the process of GM food acceptance (Mohr et al., 2007). A series of longitudinal studies commissioned by Biotechnology Australia sought to gain a greater understanding of what people think about GM technology using quantitative and some limited qualitative methods (Eureka, 2007). Overall, it was found that between 2005 and 2007 there was a significant increase in the awareness of and support for GM technology, due to numerous factors (Eureka, 2007). However, this finding may be questionable due to differing sampling methods used for each year. Other work has shown that most of the Australian publics are unaware of the nature of regulation and the organisations responsible for controlling the release and distribution of GM organisms, despite the efforts of the government and industry (Owen et al., 2005) . This work also showed that GM foods that do not offer a benefit will be avoided by the Australian publics unless there is a price discount of between 30 to 60 percent.

Work undertaken by Russell (2008) sought to gain a greater understanding of the social context by conducting focus groups in the cotton growing area of New South Wales. The purpose of this was to ascertain the direct and indirect effects that GM cotton has had on farmers and other members of the wider community, and to question the sustainability of this particular technology. Russell refers to the ‘biological embeddedness’ of crops into the social context and concluded that GM crops do have a place in the future in particular social contexts (Russell, 2008). This type of social research could be useful to predict and evaluate the potential impacts of crop technologies on particular social groups, and could be used in conjunction with scientific monitoring of environmental impacts. Overall, the number of social research studies conducted in Australia has been far fewer than those undertaken in the UK, Canada or the USA, which are reviewed in more recent articles (Costa-Font et al., 2008). Greater awareness and debate in Australia about the current and proposed use of GM products and alternative technologies across a wide range of social groups would help ascertain which technology is preferred in a particular context. It would also increase the level of understanding about the issues and concerns surrounding the different options, and determine the level of knowledge Australians have regarding current food production technologies and methods.

## What are some of the pros and cons of different food production technologies and methods? Do GM crops pose a greater risk to the environment than non-GM cultivars?

Crops produced using conventional plant breeding methods involve techniques such as mutagenesis where highly toxic chemicals such as alkylating agents capable of reacting directly with DNA are used to create mutants (Murphy, 2007). The plants are then backcrossed over many years to reduce the presence of undesirable traits. In the past, selection criteria used in conventional plant breeding have been based primarily upon yield and other traits that are desired by industry, and to provide attractive, blemish-free fruit and vegetables. Cultivars have not been selected based upon their nutritious qualities, such as the ability to uptake and sequester micronutrients, which we are now realising are deficient in our diets (White and Broadley, 2009). Although the quantity of the three main cereal crops (wheat, corn and rice) has increased the calories available worldwide, they represent a major change from the diet consumed over 15,000 years ago when humans were hunter-gatherers. These changes have increased the problem of malnutrition due to a decrease in particular amino acids, minerals, vitamins and fatty acids in staple crops (Sands et al., 2009).

Plants are immensely capable of responding to a diverse range of environmental conditions including insect attack where chemicals are produced by the plant as a defence mechanism (Hall, 2001). Is it possible that organic crops could be more detrimental to our health because of the production of such chemicals? Cultivars have not been selected because they require, for example, low rates of fertiliser (i.e. for environmental benefit), although recently some advances have been to enhance the compatibility with integrated pest management practices (Whitehouse et al., 2005). Insect and disease resistant crops have been bred for many years using conventional plant breeding techniques, however, the pest and disease organisms themselves have evolved over time to overcome these built-in defence mechanisms.

One contentious issue surrounding GM crops is whether they pose a greater threat to the environment than crops bred using conventional plant breeding methods. To some extent, both conventionally-bred crops and GM crops are grown in much the same way, usually using the same farm management practices on a large scale based upon monocultures that require large inputs of fertilisers, pesticides and water. The largest impact on the environment has occurred primarily because of farming practices and policies. Over the past 200 years, the environmental impacts of such practices have been externalised in favour of producing huge quantities of food (Lang and Heasman, 2004). The adoption of intensive farming methods in some cases have been disastrous for the Australian environment causing irreversible damage resulting from the removal of indigenous vegetation and wildlife causing soil degradation, salinity and acidification (Gray and Lawrence, 2001, Cocklin and Dibden, 2005). This has to be kept in mind when comparing the potential impacts of conventional and GM crops on the environment.

GM herbicide and pest resistant crops that are currently being grown in Australia should, in theory, have the potential to reduce environmental impacts if they are managed carefully. GM crops are a technological tool that has the potential to enhance the nutritional value of staple crops (Hilbeck, 2001, Yonekura-Sakakibara and Saito, 2006). There is conflict between scientists regarding the environmental risks that GM crops may present as opposed to cultivars produced using conventional plant breeding methods. Some suggest that the impact of GM crops on biodiversity and ecology will not be any different than traits introduced using conventional plant breeding methods (Conner et al., 2003). A review by Morris (2007) compared the potential impacts of GM versus non-GM herbicide-tolerant cultivars on the potential gene flow into other related species or other unintended environmental impacts. Numerous studies have been conducted on GM crops, however, the potential environmental impacts of non-GM cultivars have received little attention. Although this may be seen by some as a potentially contentious area, Morris (2007) reports that there is no scientific evidence that the process of genetic modification, *per se,* poses a greater threat to the environment (Morris, 2007).

Cerdeira and Duke (2006) reviewed the environmental impacts of glyphosate-resistant crops. Glyphosate is the active ingredient in the herbicide marketed as Roundup® and is a broad spectrum herbicide used to kill both broadleaf and grass weeds. They concluded that whilst these crops have increased zero tillage (a potential environmental benefit), they do pose a higher risk than conventional crops for transgene flow (introgression) into related species that may be a problem to ecosystems. Glyphosate genes themselves are less likely to be a threat in wild populations as fitness to survive is not enhanced, however the danger is that if they become linked to other transgenes that impart fitness then this could place ecosystems at risk (Cerdeira and Duke, 2006). They recommend that further research into methods to mitigate introgression be conducted to reduce the potential impacts on natural ecosytems. Warwick et al. (2008) conducted a study of gene flow in glyphosate-resistant GM canola in Canada and found that the herbicide resistant trait remained persistent over a six year period in the absence of glyphosate. They also highlighted the importance of assessing the impact of fitness enhancing characteristics such as disease or insect resistance (Warwick et al., 2008).

Clark (2006) considered that the potential risks to the environment are unique to GM crops due to the specific traits selected increasing the chance of traits being inadvertently expressed resulting in unintended consequences. Natural landraces are strains of wild crops that are indigenous to a region and exhibit a wide range of phenotypic differences that have evolved over time to adapt to changing environmental conditions. Research funding into weediness, gene flow and impacts on non-target organisms or biodiversity has been scarce especially in countries that have such natural landraces (McAfee, 2008). If genes from introduced species outcross with natural landraces, the genetic diversity of indigenous plant populations may be eroded reducing the availability of desirable genes for plant breeding.

Gene expression varies according to the environment and plants are capable of displaying considerable plasticity in phenotype and physiology changes according to environmental conditions (Billings, 1970). How plants achieve this is poorly understood. A review by Mitchell-Olds and Schmitt (2006) discusses what is understood about the mechanisms involved in the evolution and variation in ecotypes in the plant rockcress (*Arabidopsis thaliana)*. This is one of the most studied plants used in genetics studies due to its short generation time and small genome. However, there is still more research needed to understand the underlying mechanisms and processes that are responsible for the variety of ecotypes, in particular how complex traits from nucleotide sequences occur in real-world environments (Mitchell-Olds and Schmitt, 2006). The techniques used to transfer genes from one organism to another vary considerably between GM and conventionally-grown crops. Bearing in mind the complexity of such genetic and environmental interactions that may be encountered, do scientists really understand enough about genetics to predict what the consequences will be in the long term from either technique? The preceding discussion raises the question: 'Who makes the decision about what and how much scientific work needs to be conducted and what potential social impacts should be monitored in the future?'

## What are the issues associated with the management of GM and non-GM crops in Australia?

Seed crops need careful management to minimise the potential for co-mixing due to pollen transfer. The success of crops to outcross is dependant upon a range of environmental conditions, such as the quantity and spatial arrangement of related weeds and crops, humidity and rainfall, temperature, wind and the availability of pollinating insects (Rieger et al., 2002). The area needed between the parents of one cultivar and another is referred to as a buffer zone. The size of the buffer zone for commercial seed production varies according to the crop, its reproductive characteristics and the environment under which these crops are intended to be grown. Buffer zones are needed between GM and GM-free crops. A combination of knowledge acquired through experience of the seed producer, who has to meet a certain level of seed quality ascertained by quantitative tests for each batch of seed, and scientific experiments are used to determine the size of the buffer zone. This may provide useful background information for determining the size of buffer zones needed to minimise co-mixing between GM and GM-free crops.

Australian farmers do have experiences with canola and how to manage it effectively. Canola is an important crop used in crop rotation to manage diseases and improve wheat yields and as a component in integrated weed control programs. It has been found that herbicide-tolerant canola is unlikely to become a major weed if managed properly (Baker and Preston, 2008). Murray Scholz, a farmer in NSW, looked at the implications of herbicide tolerant crops in Europe, the US and Canada and concluded that Australian farmers should be allowed to use herbicide tolerant GM canola as part of an integrated weed management plan that includes the use of technologies such as pre-emergent and knockdown herbicides and crop rotation. He also suggested that it is imperative to have a minimum time limit between which successive GM canola crops can be grown to avoid the development of herbicide resistance in weeds, which he thought should be mandated by regulation (Scholz, 2008). Investigations such as this are useful as they provide information about how to potentially manage this technology. In Canada, after several years of experience growing large areas of GM crops, Clark (2006) reported concerns that some traits introduced using a GM process may pose a greater threat to the environment when grown on a large scale. It may be necessary for scientists and government agencies to monitor GM canola crops grown in Australia as large areas are now being grown in states such as Victoria and New South Wales.

Australia covers an large area with climates ranging from temperate to tropical creating a diverse variety of environments. Weather conditions can be unpredictable and may become more extreme in the future due to the effects of climate change. This makes it difficult to ascertain a generic recommendation for the size of buffer zones necessary to control the transfer of pollen across Australia. Migratory insects that are capable of carrying pollen considerable distances in a short space of time also pose a potential risk of transferring pollen from GM crops to GM-free crops especially because they can occur unpredictably in Australia. A study conducted in Armidale, NSW examined the viability of cotton and canola pollen on the proboscis of a highly mobile, nectar feeding moth (*Helicoverpa armigera*) (Richards et al., 2005). It was found that cotton pollen remained viable for 16 hours whereas canola pollen can remain viable for up to 32 hours. The quantities of pollen transported were small in comparison to insects such as honey bees reducing the potential of out-crossing. It was also reported that very little is known about pollen carried by other migratory insects. Richards et al. (2005) recommend that more scientific studies and monitoring of GM crops in Australia should be considered.

In the case of conventional plant breeding methods, the negative social impacts are negligible if inadvertent co-mixing of seed or pollen for specific cultivars occurs. However, in the case of GM crops very serious negative social impacts can occur. The ownership of patented GM crops by biotechnology companies mean that the license contract between the grower and the biotech company has to be strictly adhered to, and failure to do so can lead to serious legal sanctions. The unauthorised use of genetic material including inadvertent pollen drift from GM crops into non-GM fields, can lead to serious detrimental social consequences as growers can be sued by the biotechnology company. The quantity of GM co-mixing also has implications for its marketability according to the requirements of the buyers.

As mentioned earlier, the largest difference between the use of GM crops and those crops bred using conventional plant breeding techniques is the potential legal ramifications. Buffer zones always need to be implemented during the production of a crop to ensure that mixing between GM and GM-free crops is minimised. Organic farmers who choose to remain GM-free would lose their certified organic status if there was inadvertent co-mixing with GM crops. Studies conducted overseas have concluded that cost increases will be incurred if GM and non-GM grains are to be kept separate (Foster, 2008). It has been estimated that the costs of keeping canola crops separate throughout the handling and storage process could add 4 to 6 percent on to the farm gate price (Foster, 2006). Tests for the presence of GM co-mixing are likely to be in the order of $35 to $500 according to which method is used, which will vary according to the crop and the trait being tested and the purity level desired (Foster, 2006). These costs may be outweighed by the increased returns from using GM crops; however there are still issues to be resolved as to who should bear these costs, either the GM or GM-free farmers.

The legal system needs to be ready to address the consequences of 'human error' or inadvertent co-mixing. Deakin (2008) has written a critique of the *Gene Technology Act 2000* and has highlighted some ways in which the regulation of GMOs in Australia could be improved by drawing on lessons learnt in Europe. She is critical of the Act for failing to achieve national consistency in regulation across all states. Deakin (2008) believes that the reason the moratoria of GM were implemented across all Australian states after OGTR approval was due to failure of the Act and consequently the OGTR to address market concerns. Other concerns pertain to the lack of any system to combat regulatory conflict by establishing legally enforceable crop separation distances and a compulsory compensation fund for GM-free and organic farmers. This would minimise the chance of GM-free growers suffering any economic loss in the advent of co-mixing from pollen drift or seed spillage. It is suggested that the precautionary principle be applied in a consistent manner in Australian environmental law and emphasises the need for enhanced public participation to enable an effective regulatory framework so as to uphold the Australian public's confidence (Deakin, 2008).

## What are the potential social issues pertaining to genetically modified foods?

### How much testing is required for GM or any other foods?

At the international level, the Codex Alimentarius Commission (Codex) was formed in 1962 under the joint sponsorship of the World Health Organisation (WHO) and the Food and Agricultural Organisation (FAO). Its role is to take responsibility for the health and safety of the publics and ensure fair trade practices by establishing appropriate standards. Since inception, Codex has created over 4,000 standards and guidelines for foods and food labels, contaminants, additives and residues. Representatives from national governments along with standing and working committees assisted by experts from scientific and civil society groups and industry are involved in drafting and re-drafting proposals. The process of reaching a consensus can take over six years to develop and implement (Kalaitzandonakes and Phillips, 2000).

There are differences in opinion about the international regulation of GMOs. Some authors have stated that to date there are no commonly accepted international methods to assess the safety of complex plant foods derived via novel or other plant breeding methods (Knudsen et al., 2008). Others argue for more testing of all new conventionally bred plants and say that there is general consensus between scientists globally on how to assess GM derived food products, despite disputes on minor issues (Kok et al., 2008). A lack of consensus globally could potentially impede the global trade in GM foods. Having said this, it may be very challenging to achieve due to the variability caused by genetic and environmental interactions in GM plants and the genetic diversity of human populations that may react differently to allergens. The same problem exists for foods produced using conventional breeding methods.

Food Standards Australia and New Zealand (FSANZ) is a federal agency located in the Department of Health and Ageing, and regulates the food industry. This agency is responsible for the establishment and maintenance of food safety standards and labelling. The risk assessment of GM foods is determined by scientific means based upon ‘substantial equivalence’. This determines if the basic components and propensity for allergic reaction to novel food do not vary significantly from foods derived from conventional plant breeding methods. All GM foods are subjected to rigorous testing by FSANZ which compare the composition of the main macronutrients such as proteins, fat, carbohydrates and fibre along with micronutrients (Knudsen et al., 2008). In some cases, the results of animal studies and experiences of human exposure are taken into account. This approach forms a benchmark for judging the comparative safety of novel foods. However, it is difficult to define as it does not consist of an accurate checklist of criteria that should be used for safety assessment. If a novel or GM food is introduced into a new cultural environment or subjected to processing techniques that differ from the 'history of safe use', then additional safety information may be sought as susceptibility to anti-nutrients, toxins and allergens can vary for different populations (Constable et al., 2007).

Most plant foods do not have a scientifically validated history of safe consumption, despite being consumed for several centuries due to the difficulty of obtaining pertinent scientific data. To establish a history of safety, factors such as the period over which the traditional food has been consumed, intake levels, preparation methods and composition are used. Changes to the metabolic components of food resulting from the use of any breeding method have received very little attention. One potentially useful instrument for detecting unintended effects is the technique referred to as metabolomics (Kuiper et al., 2004, Rischer and Oksman-Caldentey, 2006). This method involves generating the profiles of secondary metabolites and produces mainly profiles of low-molecular weight molecules, that may be related to plant phenotypes (the physical traits of the plant) and nutritional characteristics (Kok et al., 2008). It generates large quantities of complicated data, the processing of which needs to be refined before it can be accurately and confidently applied (Dixon et al., 2006, Kok et al., 2008).

This raises the question 'How much testing is required for novel or GM crops or any other foods?' Answering this question is complex. As mentioned before, foods produced using conventional plant breeding methods may involve the use of highly toxic chemicals to create mutants, with potential health implications for those who consume the food products derived from these plants.

## Is post-market surveillance needed?

Post-market surveillance, as referred to here, implies that monitoring occurs after the product has been purchased by the public. Some commentators suggest that despite several agencies in different countries undertaking some form of monitoring, there is an urgent need for the development of an internationally harmonised framework for the safe handling of GMOs (Singh et al., 2006). There has been very little monitoring of potential environmental or health impacts in countries such as the USA, Canada or Argentina, making it difficult to ascertain whether there are any benefits or undesirable impacts caused by GM crops and foods.

The philosophy of substantial equivalence has been criticised for its poor scientific premise. Millstone et al. (1999: p.526) argue that “scientists are not yet able to predict the biochemical or toxological (sic) effects of GM food from knowledge of chemical composition”. The testing methods for novel foods have been criticised as being not based on sound science as only some novel foods are subjected to animal trials and trials are not conducted on humans (Carmen, 2004). It has been pointed out that animal testing, if undertaken, may only be for a limited period of time, with the animals being assessed and usually put-down before any cancers, for example, have had time to develop. This obviously prevents any further measurements on reproductive capacity or the health of subsequent generations of these animals (Carmen, 2004). Carmen recommends that independent epidemiological tests be conducted on survey populations to detect unintended effects instead of waiting for a ‘critical mass of clinicians’ to recognise a recurring symptom. In other words, numerous cases have to be noticed and communicated between members of the medical profession before any effects are documented. FSANZ also recognises that there is a need for post-market monitoring of potential unintended long-term health impacts of new foods (Brent et al., 2003).

A process for post-market surveillance has been developed in Europe in the belief that post-market monitoring could serve to back-up pre-market safety assessment. It may also be a dietary surveillance tool that could assist in the evaluation of public health targets (Hepburn et al., 2008). Canada proposed a case-by-case post-market monitoring system to assess the impact of novel food on dietary consumption patterns, and to evaluate the potential effects changes may have on the health status of the population (Hlywaka et al., 2003). Other authors suggest that a post-market surveillance system would assist policy-makers and could capture information about any benefits. It would also serve as a mechanism that would allow any adverse long-term effects to be detected and acted upon (Amanor-Boadu, 2004).

A comprehensive review of tests carried out on GM foods is documented by Magaña-Gómez and Calderón de la Barca (2009). These tests are far from conclusive as the sample size, test animal, and methods vary substantially. The number of tests that show significant and non-significant findings is similar (Magaña-Gómez and Calderón de la Barca, 2009). A standard methodology would have to be established, accepted and applied by other countries that specify the sample size, test animal and other parameters. Prevention may be better than cure in terms of any adverse effects, and if citizens want such testing to be conducted, and are aware of the costs involved, then this additional work may be an appropriate course of action. Who should be responsible for the costs if they were considered to be desirable? There is also the question of who would undertake the tests. Would testing by an independent body be the preferred option?

Biotechnology companies presently are not at liberty to disclose safety testing results to the public and are not generally not open to scientific peer review (except by FSANZ). FSANZ can review the published scientific literature and information from other agencies including independent scientists. Biotechnology companies face a double edged sword that creates a divide between commercial privacy to prevent breach of patent rights, versus the possibility of gaining or otherwise, trust in the products they are trying to develop and sell. Drug testing for example is carried out over many years and costs millions of dollars by the manufacturing company. Patent legislation over drugs commercialised ensures that costs are recovered which is viable as they constitute a low volume high value product. If GM foods were to undergo similar testing even on a reduced scale, what would the costs be? These prices may trickle down to the public probably making products too expensive and inaccessible to most and resulting in a significant financial loss to the technology developers. Is labelling a satisfactory alternative that helps preserve citizen autonomy? All these questions still need addressing.

## Should GM foods be labelled?

As mentioned previously, Codex has the task of developing international labelling standards for GM foods. Much of the debate revolves around whether GM foods should be treated as the product or as the process involved in their creation. If the actual food were to be treated as the product, it would have to be labelled when it was determined not to be substantially equivalent to products produced by conventional plant breeding methods. The process approach would require all food and food ingredients to be labelled regardless of resemblance to conventional crops (Kalaitzandonakes and Phillips, 2000).

A review of labelling across the globe has been reported by Gruère and Rao (2007) who concluded that requirements vary considerably. Despite many developed countries implementing mandatory labelling policies, the issues over which foods or feeds it is to be applied to, what threshold levels, and whether it is the product or process of GM techniques, vary considerably. Where labelling regulations exist, implementation has been found to be ineffective and increased provision of information and choice for citizens has, in many cases not increased. Few developing countries have introduced labelling with only a small number managing to implement regulations (Gruère and Rao, 2007). The costs and benefits of labelling options around the world are unevenly distributed among the technology developers and agricultural exporters and importers making it extremely difficult for Codex to find a consensus. The wide range of consumer perceptions about science and its products adds to the difficulty (Gruère and Rao, 2007).

Consensus on labelling still remains an issue and the costs, especially for developing countries, may prohibit further development. Markets are socially constructed and embedded into the socio-political environment in which they exist, as are the buyers and sellers involved. Labelling may be a double-edged sword in shaping the market towards non-GM products, especially in countries where the public is sceptical of GM, and may result in an increase in the price of foods in general as processors will be forced to focus on the source of individual ingredients (Bender and Westgren, 2001).

In Australia, GM foods are required to be labelled if a food ingredient or processing aid contains novel DNA and/or protein, or has altered characteristics that are present in quantities above one percent of the total product. In 2001, FSANZ ruled that GMOs could only be supplied to a domestic market after approval had been granted and mandatory labelling applied (except animal feed) to foods that posses GM protein or DNA or have altered characteristics (Anderson and Jackson, 2005). There are a range of products that are derived from a GM process available on the shelves of Australian supermarkets. These include products manufactured from soybeans, corn chips and potatoes or sugar beet, often present as an oil or syrup. As oils processed from GM crops contain only a trace of modified DNA, they do not have to be labelled, and are not subject to routine testing requirements.

Many Australian citizens are unlikely to be aware of the fact that they are already consuming products derived from a genetic engineering process, and may decide that they are willing to pay more for foods in order to have such information provided. Cotton seed oil is more likely than other vegetable oils to be a product of a GM process as the majority of cotton grown in Australia is genetically modified. In 2003, it was estimated that 10 percent of vegetable oil in Australia was derived from GM crops (Marohasy, 2003). Previous work conducted in Australia has shown that the labelling of GM products was regarded as crucial, and anger was expressed about GM foods being inadequately labelled (Dietrich and Schibeci, 2003). Greenpeace has released figures from a report they commissioned from the market research company, Newspoll, indicating that 90 percent of citizens would like to see labelling of these GM products. Interestingly, only 54 percent said that they would avoid GM products whereas 42 percent said it would make no difference (Newspoll, 2008). In 2003, an online poll conducted by CHOICE indicated that both the process and the product of GM were of concern, and 75 percent of respondents thought that GM canola oil should not be exempt from being labelled as ‘GM’ despite the absence of GM proteins (Hughes, 2008). The report commissioned by Biotechnology Australia found that the public thought that GM foods were prevalent in our food supply and that they were being misled into consuming GM products and were concerned about the lack of labelling that would give them informed choice (Eureka, 2007). The results of the case study also indicated the desire for more comprehensive labelling for GM foods to enable people to be able to make an informed choice. There is still more work needed to ascertain what specific attributes the Australian publics actually want to see on food labels.

Other authors state that positive labelling enhances consumer autonomy and facilitates participatory decision-making and informed consent between the public and the biotechnology companies (Jackson, 2000). Achieving this type of social contract would give biotechnology companies more incentive to educate the public about the safety of their products to mitigate any adverse reaction to labelling, whereas resistance would only increase public distrust. In Australia, new biotechnology products are being awarded patents without addressing ethical, social and environmental concerns. It has been suggested that public policy issues should be addressed early in the patent process (Forsyth, 2000).

Is the fact that GM products do not have to be labelled (unless it contains more than 1 percent GM product) an example of 'market failure'? Despite the desire for labelling by some citizens, and the cries of activists attempting to place the issue back on the political agenda, industry has failed to respond. MacDonald and Whellams (2007) argue that it is not the ethical obligation of individual companies to label foods as the 'Product of Genetic Engineering' because of the lack of evidence to suggest that these products are harmful to health, and in the interests of preserving the autonomy of the companies developing GM products. They also think that they should not be burdened by any additional costs that might be incurred. They regard the public as not having the 'right' to know even though they may have an interest in knowing. For many citizens, labelling is not associated with risk but relates to autonomy, freedom and control, and the moral issue of having a right to know what they are consuming. This viewpoint offers validity only if the assumption that food safety tests are thorough enough to detect immediate and long term effects is correct (MacDonald and Whellams, 2007). If not, then companies would be ethically wrong not to label in the first place.

Presently, ‘negative’ labelling ‘GM-Free’ is permitted on a voluntary basis by the Australian Competition and Consumer Commission (ACCC), which may offset the potential efforts by FSANZ to introduce positive labelling if they attempt to do so. I have observed an increase in GM-free labelling on canola oil products over time (Figure 2.3). Oils from other plant sources tend not to carry labelling about whether they are GM or not. To add to the confusion, some canola products are labelled GM-free whilst other plain packaged home brands are not. Woolworths, for example, do not label their home brand canola oils, but do have a GM-free label on Tablelands margarine which is exclusively sold in Woolworths stores. This may draw attention to some members of the Australian publics that canola may be a product of GM since GM canola is now being grown in larger proportions of Australian farm land since most state moratoria have been lifted. It is important that labelling of GM products is consolidated into one institution otherwise further public confusion may result. More understanding about the wishes of the public regarding the labelling of GM foods may mitigate adverse reactions if the Australian publics become aware that GM products such as cotton seed oil are being used already. Acceptance of second generation GM technologies which offer a direct benefit to the Australian publics may be compromised if this is not determined.


Figure 2.3: Some examples of canola products labelled as ‘Non-GM’

Source: author

## Conclusion

The way in which food is produced, processed and consumed directly affects social patterns of behaviour according to the values and beliefs associated with a particular culture. GM technology offers an alternative method of food production to conventional plant breeding techniques. It has been widely used in some countries whereas others have not accepted it for a variety of reasons, some of which relate to differences in the way different social groups conceptualise risk. Scientists generally have a narrower, more objective view towards risk based upon parameters of harm and benefit, and report their findings in a technical way which is often only meaningful to other members of the scientific community (Savadori et al., 2004, Raybould, 2007). This can be problematic to policy-makers and other groups who wish subjective values to be considered. A limited number of predominantly quantitative social research studies have examined the attitudes of Australians towards GM technology. Some results indicate that attitudes are currently more positive than in previous years (Eureka, 2007), however, more work is needed in this area. More understanding and debate about current and future food production methods and techniques may help ascertain which technologies would maximise social outcomes.

The potential environmental impacts of cultivars produced using GM techniques have received far more attention than those bred using conventional plant breeding methods. The movement and persistence of genes from GM plants such as canola into related species has been demonstrated (Warwick et al., 2008), however, there is a lack of consensus between scientists as to whether GM crops pose a greater threat to the environment than non-GM varieties (Conner et al., 2003, Morris, 2007). The amount of research that should be undertaken in this area remains a contentious issue. The cultivars produced using either plant breeding method are essentially grown and managed using the same farming methods. These methods in some cases have caused the largest detrimental impact on the Australian environment over the past 200 years.

The main difference between the two breeding methods are the potential social impacts due to inadvertent co-mixing or pollen drift because of the legal ramifications that are implicit to GM crops. The *Gene Technology Act 2000* and the OGTR does not have provision to address these problems, meaning that there are currently no regulations in place to compensate GM-free and organic growers (Deakin, 2008). Despite many Australian farmers having considerable experience growing canola, the distances needed between GM and GM-free crops has not been fully established or legislated, and the costs for testing purity thresholds have not been allocated to either party.

There are concerns raised by some authors that GM foods pose a greater threat to health than foods sourced from conventional methods and suggest that they should be subject to post-market monitoring tests to detect any adverse affects, and assist in the evaluation of public health targets (Amanor-Boadu, 2004). To date, testing methods have varied considerably and a standard for the sample size, test animal, and methodology remains unresolved (Magaña-Gómez and Calderón de la Barca, 2009). Taking into account the range and complexity of genetic and environmental interactions that occur in plants, humans and animals, do scientists understand enough about the underlying mechanisms to predict any unintended impacts of new GM (and non-GM) technologies? Who and how should make the decisions about what and how much scientific research is needed to monitor impacts, inform policy-makers to protect the environment and maximise social outcomes?

The labelling of GM foods is a contentious and ethical issue which goes beyond objective scientific parameters involved in food testing: it is intrinsic to subjective human values related to the techniques involved in the production of food. These are all social issues that may need further review if GM technology is to be successfully embedded into Australian society in the future. Failure to address the issues surrounding first generation GM products may prevent the potentially more acceptable second and third generation products reaching commercialisation.

# Chapter 3 – Introduction to technology, Technology Assessment (TA) and food policy in Australia

This Chapter provides some of the definitions of technology and two different approaches which provide greater depth and understanding are outlined. The first originates from the work of Pinch and Bijker (1987) and attempts to comprehend the pattern of technological development using an agency-centred approach referred to as the social construction of technology (SCOT). The second approach introduces an alternative perspective to technological change developed by Dosi (1982), referred to as technological paradigms. Technology creates feelings of wonder and curiosity as well as anxiety and fear (Mordini, 2007). There are many reasons for such emotions, for example, how to control it in the neo-liberal marketplace where commercial profits often dominate over the public good. This poses problems for governments on how to regulate new technologies to maximise social outcomes. In response to these problems, a process referred to as technology assessment (TA) was developed and has since evolved to fit into particular social and political contexts. The different approaches and tools that can be used are discussed.

The next section provides an overview of how a new food technology was introduced into Australia. The implementation of the controversial biotechnology policy into Canada is compared with the introduction of this policy in Australia. The challenge governments across Australia face is how to produce policies that reach a balance between supporting the global food industry that is central to our economy, and also protect human health. This has led to a fragmented array of policies that have been developed by different departments for agriculture, food and health. This is discussed with a view that a process of vision TA may be useful as a way of exploring alternatives and developing a shared vision for the future of food in Australia. This may provide a knowledge base that could feed into the existing policy-making process to improve upon the current bureaucratic system, and enhance democratic principles by broadening the range of stakeholders in the decision-making process starting with agriculture of food research.

## What is technology and why can it be problematic?

There is no one single definition or meaning associated with the word ‘technology’. Technology could be viewed simply as an object or artefact that is the product of research and development that has emerged according to its own trajectory. To view it as such, however, fails to acknowledge the social and political context that develops along the same trajectory under a constant process of coproduction or mutual shaping (Russell and Williams, 2002). Technology can only come into being if the social, political and economic context is conducive to its development and adoption at any given time. The context and technology does not arise *ab initio,* but are born where the social, economic and technical relations already exist (Bijker, 1992a). Technology is embedded in society and institutionalised, in other words it does not drift freely around society due to its grounding in institutions by certain groups (Westrum, 1991). Westrum (1991, p4) also describes “technology and society as being forces that together shape the world in which we live. The two intertwine, when one changes, the other is also likely to change.”

The Technology Assessment in Social Context (TASC) project, which was initiated in takes a broad view of technology, which:

> Comprises the products and processes of the application of human ingenuity for a particular purpose; and the knowledge, designs, standards, procedures and applications associated with that creation; and the social arrangements specifically associated with that creation (Russell et al. 2010, p112).

According to Mordini (2007):

> Technology is a social practice that embodies the capacity of societies to transform themselves by creating and manipulating not only physical objects, but also symbols and cultural forms. In its essence, technology is power Mordini (2007, p544).

Symbols underpin all human activities; some are shared by the entire species or a specific culture forming a collective imagery and narratives, giving sense in a particular context. Collective imagery is made up predominantly by stories providing a lens through which people perceive and understand the world. Stories are powerful influences that shape actions, relationships and commitments that can demand reflexivity and accountability of policy-makers who may have to change science policy. According to Mordini (2007), an object becomes a technology when it acquires a symbolic dimension which has meanings that reach far beyond its specific use or level of complexity, and sometimes beyond its creator's awareness.

Mordini (2007) reviews some of the problems that technology can create in a particular context, which can lead to anxiety and fear. These emotions conflict with other powerful positive emotional forces: wonder and curiosity. Many people feel uneasy with technology and have trouble coping with constant change and the associated anxiety as they wonder what the invisible risks could be (Mordini, 2007). The rate of technological change challenges implicit and explicit moral assumptions making it imperative for scientists and policy-makers to communicate with the public and not dismiss their narratives as being naïve. This will help them understand people's thoughts and feelings, and according to Mordini (2007) help stimulate wonder and curiosity, which may be the best way to help overcome fear and paranoia about new technologies.

Science can often result in the need for more science to fix the impacts that technologies have caused. Edward Tenner (1996) in his book, *Why Things Bite Back*, refers to the way in which new technologies are developed to reduce the impact of existing technologies, but the process results in the creation of another impact requiring another technical fix. He refers to this as the 'revenge effect'. One example is the use of asbestos which promised protection from fire and heat. It was used in a wide range of technologies such as the brake shoes of trains to prevent overheating and in the linings of theatre curtains as a fire shield. In the 1980s asbestos was found to be the cause of a lethal form of cancer called mesothelioma (Tenner, 1996).

Another concern with technology revolves around those who control it and whether research is undertaken which is contrary to the public good. The neo-liberal economic context in which trade occurs has been conducive to the rise of companies which, through the process of vertical (between sectors) and horizontal (within particular sectors) integration, dominate the marketplace and have often been the focus of criticism for a number of reasons. Many multi-national companies are regarded as being beyond the control of governments (Kellow, 2002), and hold a disproportionate share of power in the marketplace. For example, some 85 percent of grain trade is in the hands of six corporations (Gupta, 2004), as are genetically modified foods with Monsanto holding 90 percent of the GM crop market (Foster, 2008). There has been a trend towards collaborative research projects between government, university and industry, often with some university researchers being funded by industry making them obligated to serve the interests of these organisations which may be contrary to the public good (Caldart, 1983). University-based research has been traditionally characterised by long-term projects conducted to serve public needs and intellectual enquiry and promotes open scientific communication and free use of knowledge (Caldart, 1983).

Company-based research is usually orientated towards profit-making and secrecy (Caldart, 1983). The growing intensity of work conducted between universities and industry has been a cause for debate surrounding the changing norms and practices of scientific work. Academic scientists have been accused as being active agents seeking to increase their influence on business by shaping the relationship between science and industry making it easier to protect and negotiate their role identities (Lam, 2010). Agricultural biotechnology research has caused particular concern as it is market oriented and usually involves patents. The scientific community must be mindful of the social impacts, and be reflexive about the potential ethical and moral consequences of their work. Science is value laden and increasingly influenced by commercial interests, and scientists are urged to exercise ethical caution to ensure that science is not conducted just because it is possible (Early, 2002). The push for scientists to gain industry funding may result in research that is not in the interests of the public (Nestle, 2007). Alliances with private enterprise can lead to a conflict of interest that is inherent when accepting food industry funding and researchers should be mindful not to lose sight of the impact that food marketing practices can have on public health (Nestle, 2007).

Governments are facing a challenge to regulate such a complex system in a democratic manner to minimise the impacts of new technology on society. The emergence of technologies into a de-centralised marketplace involving many actors and agencies makes scientific governance problematic. How can policy-makers decide which technologies should or should not be introduced? This led to the development of the so called ‘expert system’ where experts are used to replace traditional democratic decision-making processes (Mordini, 2007). Expert status is a social construction that gives a particular individual or group a higher level of authority and power over others referred to as ‘non-technical’ or ‘lay-people’. Experts have an air of authority in a conversation, which can be achieved by using credentials that reflect a level of knowledge, skill and experience, or jargon that may frustrate or anger the listener resulting in them disengaging (Rifkin and Martin, 1997).

Traditionally, risk communication from scientific experts, authorities and private enterprises is conducted by presenting ‘rational’ facts directed at changing ‘irrational’ opinions of risks to persuade people to change their subjective views to follow objective scientific evaluation (Liu et al., 2009). Education is not a one-way process and some areas, for example the biotechnology industry, need to listen to its public and increase their understanding of ethics. By doing so, the ethical dimension is seen as intrinsic rather than extrinsic to its aims and moves away from thinking in terms of the ‘information deficit’ model (Bruce, 2002). The ‘deficit model’ assumed that provision of more knowledge about science to the public will alleviate any concerns and enhance public trust (Wynne, 2006). Wynne suggests that scientific and policy institutions should be self-reflexive about their assumptions and expectations they have about their science in the public arena, as this would be a far better way of increasing trust. Scientific culture which embraces science as being factual, objective, knowledge-seeking pursuit of truth on the one hand, and perceives an intellectually empty, emotional lay public on the other hand also needs to be changed (Wynne, 1996, Wynne, 2001).

The scientific community are a powerful group who are highly influential in the policy-making process. Demortain (2008) analysed how the power of scientific experts influenced the emergence and establishment of standards for food hygiene. The principles of Hazard Analysis Critical Control Point (HACCP) are used worldwide throughout the food production chain to monitor and correct potential risks. One factor involved was the formation of a social polyvalence of scientists working simultaneously or successively with a multitude of standard-setting organisations and businesses (Demortain, 2008). There was a systematic delegation of specific functions to individual scientists recruited for the quality of their work in both national and international public authorities. The scientists were able to mediate between potential standard-setters and users in a horizontal process of generification that involves the replication practices, objectives and standards that are characteristic of the scientific community. For example, egg producers are encouraged to detect and identify sources of egg contamination but are not advised to keep records or establish contamination thresholds, thus indirectly legitimising the development of HACCP principles (Demortain, 2008).

Policy-makers can remove normative disputes from the political agenda by demanding technical solutions to political problems (Fenna, 2004). Technocratic, top-down policy-making based upon science is not always suitable for a range of situations. Sabatier (1986) suggests that top-down approaches are only appropriate in cases where there is a dominant piece of legislation that structures a particular situation, and when research funds are limited and mean (average) responses are sufficient. Bottom-up approaches that stem from the community are more appropriate when dominant legislation is absent and the dynamics of the local situations is important (Sabatier, 1986).

### Approaches that provide greater meaning to the concept of technology

The definitions of technology may perhaps not be all that useful *per se* MacKenzie and Wajcman (1985) viewed technology as consisting of three layers. The first layer relates to the physical object or artefacts, the second refers to the activities or processes involved in its making, and the third encompasses the knowledge involved in the design or operation of the object (MacKenzie and Wajcman, 1985). One approach that has attempted to comprehend the pattern of technological developments using an agency-centred approach is the social construction of technology (SCOT). The conceptual framework underpinning SCOT was developed by Pinch and Bijker who conducted studies on bicycles, bakelite and florescent lighting (Pinch and Bijker, 1987, Bijker, 1992b, Bijker, 1997).

Their view centres around the idea that the nature of the technology is determined by a network of interested parties that decide the important characteristics of a device or system, and how it needs to be evaluated and improved. The final artefact is determined by negotiations, meanings and observations made by particular groups.

Another component of the SCOT framework involves closure, where multi-group conflicts relating to the image of the artefact are resolved to the point where additional modification is no longer necessary. Adding to this is the concept of the wider socio-political context in which the development of the artefact occurs, which includes the groups' relations to one another such as power differences, which are often invisible to others (Pinch and Bijker, 1987). The SCOT perspective for analysing technology development has been useful because of its focus on the social interactions that occur between particular social groups which are not necessarily influenced by external factors, for example, market demands. Although SCOT has been useful, it has also been criticised for not identifying issues such as the influence that social structures and power relationships have on technological change (Klein and Kleinman, 2002).

An alternative theoretical perspective to technological change was developed by Giovanni Dosi (1982) and is referred to as technological paradigms. This focuses on economics and how technological changes occur within firms which seek to build and diversify their technology. The term relates to the patterns used to find solutions to techno-economic problems (Dosi, 1982, Dosi, 1988). The selective principles involved comprise of the artefact and a set of heuristics that seek answers to questions like 'where do we go from here?', and 'what should we search for and where?'. Within each technological paradigm there can be several technological trajectories or pathways to find the answers. These can exist at many levels, for example, within specific industries, companies or entire countries enabling technological change to occur in response to external market demands and conditions by building upon existing technologies. However, technological progress can only radically change direction if other emerging paradigms can be fostered.

Dosi (1982 p153) states that:

> A technological paradigm has a powerful exclusion effect: the efforts and the technological imagination of engineers and of the organisations they are in are focused in rather precise directions while they are, so to speak, 'blind' with respect of other technological possibilities. Dosi (1982)

The approaches of SCOT and technological paradigms can be useful to help policy-makers, scientists and industrialists understand the relationships between stakeholders and how they affect innovation processes. This may help avoid mistakes caused by the assumption that the purpose and outcomes of innovation and design are shared by stakeholders, which may minimise the occurrence of counterproductive processes (Olsen and Engen, 2007).

The complex interactions that occur between science and society pose a challenge to policy-makers about how to govern technology in a way that maximises social outcomes and minimises negative impacts. What type of framework could assist policy-makers and experts to communicate with people, learn from them, and create a more democratic arena that facilitates a decision-making process that encompasses views from a broad range of social groups? I suggest Technology Assessment could contribute.

## What is Technology Assessment (TA)?

The initiation of TA can be traced back to the late 1960s in the USA after fears that technology may end up in technology 'arrestment' if the US congress did not develop a better system of policy analysis. Concerns were also expressed as to how to help society cope better with technology especially when it was introduced by free enterprise organisations (Porter, 1995). The motives behind the creation of the US Office of Technology Assessment (OTA), which commenced in 1974 and closed in 1996, were based upon the need to make technology more useful and socially acceptable, and to inform legislators about matters arising from science and technology (UN/OTA, 1991) .

An OTA workshop report (1991, p4) considers that Technology Assessment:

> ultimately comprises a systems approach to the management of technology reaching beyond technology and industrial aspects into society and environmental domains. Initially, it deals with assessment of effects, consequences, and risks of a technology, but also is a forecasting function looking into the projection of opportunities and skill development as an input to strategic planning. In this respect, it also has a component both for the monitoring and for scrutinising information gathering. Ultimately, TA is a policy and consensus building process as well (UN/OTA, 1991).

The functions of the early TA were to serve as an early warning system based upon a technocratic system of 'expert' scientific methods and modelling (Medford, 1973). One of the weaknesses of the OTA approach was the assumption that technology was implicitly linked to 'progress', which led to the failure to acknowledge the complex social changes that occur after the introduction of new technology, and the political motives of the actors who were responsible for its development (Guston, 2004). Criticisms led to the OTA broadening the stakeholder base to encompass a wider range of 'expert' views which enabled it to operate for another couple of decades (van den Ende et al., 1998).

TA has evolved since these times as public concerns grew in response to new developments such as biotechnology and more general concerns about how to manage scientific research conducted by collaborative partnerships between industry, universities and government. Many types of TA emerged depending upon factors such as the social and political context, the audience or the phase of the technological development. Whichever form of TA is used, generally TA is about forecasting that allows monitoring with the aim of developing a feedback system to facilitate group learning. Although the term 'social learning' is not explicitly referred to in much of the literature, writers consider that TA is a social learning process (Wynne, 1995).

Governments are responsible for creating innovation policy that is supported by all actors involved, and for creating an environment that enables the appropriate level of interaction to facilitate learning from each other with the aim of formulating technology paths that attract widespread support (Goorden, 2004). Such information is needed by policy-makers to assist in the policy-making process. TA is an instrument to render possible the making of responsible decisions concerning new technological options (Skorupinski, 2002). During the 1980s, TA was used as a policy instrument to assist policy-makers in decision-making about various innovations because TA is a form of policy analysis. It provides a systematic process of predicting and evaluating the consequences, direct, and indirect, intended and unintended, beneficial and adverse of technological change on all relevant sectors of society (Lee and Bereano, 1981).

Europe embraced and developed TA approaches to widen the debate about the governance of science and technology to include other stakeholders, and sought to increase public involvement and understanding in a process referred to as participatory TA (Hennen, 1999, Durant, 1999). Other approaches were developed by different countries, for example, the Dutch promoted communication between stakeholders and the public with the technology developers to increase their influence on its development. Interactive TA (Grin and van de Graff, 1996) sought to promote interactions and communication early in the innovation process. Constructive TA (CTA) was widely used in Europe by the late 1980s. The aims of this form of TA were not only to include a broad range of relevant stakeholders early on in the development process, but also to deliberately incorporate a variety of heterogeneous actors whose different backgrounds and views highlighted knowledge gaps, and different ways of assessing technologies. Differences were addressed by creating a (carefully facilitated) arena where actors could interact in a constructive way to broaden their understanding of other actors' views (van Merkerk and Smits, 2008). The process increased the influence of social groups to enable a technology to be shaped from the onset by a process of co-creation (Rip et al., 1995, Genus and Coles, 2005, Genus, 2006). Another form of TA developed later in the USA, real-time TA, focused on integrating natural science and engineering with social and policy research from the outset (Guston and Sarewitz, 2002). Guston and Sarewitz (2002) describe real-time TA as being a research program proposed to integrate natural science and engineering investigations with policy and social science at the research initiation phase. This necessitated the building of a reflexive capacity into the research enterprise to encourage more effective communication between stakeholders and increase the available information about their capabilities, preferences and values. The aim of this is to enable innovation paths to be shaped and modulated in response to ongoing analysis and discourse.

TA can be used to forecast *probable* future developments by extrapolating current trends into the future so that actions can be adjusted to avoid or encourage probable developments (Roelofsen et al., 2008). This can be achieved by using, for example, science-based models.

TA can also be used as a framework for vision assessment. Each individual possesses their own personal thoughts and feelings about how the future should or should not look like, which may be shared by others in a particular social group. This may include ideas about future energy sources, water supplies or food production. It has been hypothesised that we can shape our society even though the social processes involved during the creation of a technology are, essentially, embedded in institutions where multiple actors are engaged (Grin, 2000). Vision assessment requires us to critically reflect upon our visions with the aim of shaping them and influence social development. Grin (2000, p11) remarks that

> in other words: the question is not whether it is possible to shape our future according to some shared vision, but rather whether it is possible to shape the visions that are guiding us into ones that we like better. Another question is how to shape visions without running into the acceptability problems that we just indicated for existing utopia's (sic).

In order to create a better future, existing dreams may have to be broken down. The analysis of *possible* futures uses approaches based upon scenarios and uses both science-based models and participatory techniques (Roelofsen et al., 2008). This means that scientific and non-scientific knowledge is used to assist decision-makers and influence decision-making (Roelofsen et al., 2008).

## TA Tools

TA uses a range of tools some of which are summarised in a report prepared by the Agricultural Economics Research Institute in the Netherlands, titled *Ethical Bio-Technology Assessment Tools for Agriculture and Food Production: Final Report Ethical Bio-TA Tools (2006)* (http://www.ethicaltools.info). This European Commission funded project was initiated to develop and improve ways of assessing ethical concerns associated with new agricultural and food production, especially biotechnologies. This was deemed necessary to inform government regulators and assess the general public and actors in all segments of the food chain to improve transparency and communication. There is no single way to do this, so a 'toolkit' of assessment tools can be used to form decision-making frameworks, methods for public consultation and communication through the food chain. Another comprehensive toolkit is available from the Flemish Institute for Science and technology assessment http://www.viwta.be/content/nl/inf_viWTA.cfm. This site also details TA tools and procedures that can be used. The tools used to form decision-making frameworks can include, for example, the conduct of a stakeholder analysis, or using the Delphi method. The Delphi method is an iterative process of communication to exchange the views and thoughts of experts either anonymously using the internet, or face to face over a given time period.

Another tool to assess the opinions of interest groups and thresh out intrinsic concerns is by using an ethical matrix. The aim of this method is to raise awareness and encourage ethical reflection in a structured manner. People are asked to look at how different aspects of the technology affect other parties including animals and the environment with regard to autonomy, fairness and well-being. The philosophy underpinning the ethical matrix was developed from the field of biomedical ethics. According to Beauchamp and Childress (1994), the principles of biomedical ethics encompass: (i) the Hippocratic notion of non-maleficence, that we ought not to harm others; (ii) beneficence, that the benefits outweigh risk and costs; (iii) the Kantian notion of autonomy where respect is given to individuals; and (iv) the Rawlsian theory of justice which addresses norms for distributing benefits, risks and costs.

Food ethics has emerged as another branch of applied ethics and differs from biomedical ethics in that everybody has to consume food to survive and comes into contact with either the production, distribution, storage, retail or processing of food. Mepham (2000) expanded on the four principles above to produce an ethical framework for food that includes a wider range of stakeholders than the medical arena. Mepham (2000) combined the principles of respect beneficence and non-maleficence to simplify the utilitarian notion of respect for well-being intended to include terms of human stewardship over organisms, producers, consumers and the biota, that may be affected by the food production cycle. In the case of the biota, the objective analysis of justice relates to the sustainability of biotic populations. For the consumer, justice underpins the universal affordability of food (Mepham, 2000).

The overall process of ethical evaluation means ranking the different impacts according to different stakeholders' perspectives relative to a pre-existing condition. The results will vary according to the nature of the proposed technology, worldviews and whether stakeholders prioritise the short or long term impacts. Whilst Mepham (2000) recognises some limitations to this framework such as the difficulty of achieving consensus in groups with polarised worldviews, it can still be a useful tool to assist in food policy decision-making. More recently Small and Fisher (2005) applied a score system to the ethical matrix to create the ethical valence matrix. This was proven to be a useful quantitative tool to measure employees' ethical attitudes towards a controversial transgenic cattle project in New Zealand (Small and Fisher, 2005). This technique has been used for technologies such as genetically modified fish to determine the implications for aquaculture (Millar and Tomkins, 2007) and for assessing agricultural biotechnologies (Beekman and Brom, 2007, Talukder and Kuzma, 2008). A good example of a technology oversight system which uses multiple frameworks, institutions and stakeholders has been proposed by Talukder and Kuzma (2008). They have developed a comprehensive system to evaluate the introduction of GM cotton in India using four established frameworks to assess risk and risk management, identify regulatory oversight, consider various policy options, and address ethical issues (see Table 3.1) (Talukder and Kuzma, 2008). The ethical matrix identifies the stakeholders and gives consideration to the effects on animals and the biota and how they may be positively or negatively affected according to ethical parameters, for example, autonomy and justice.

There is a range of tools to facilitate active public involvement in decision-making that share many of the features of deliberative democracy. One method is to conduct a consensus conference where the public are informed about the issue to be addressed by way of presentation, or by providing documents. The publics are then asked to form an opinion about the issue which is given to a panel of selected experts to consider. Their answers can be fed back to the public and issues debated further between the participants. This can be an expensive and time consuming process, but is an effective participatory method.

Table 3.1. An example of an ethical matrix used for Bt cotton in India taken from (Talukder and Kuzma, 2008).

| Stakeholders | Welfare as eliminating negative utilities | Welfare as promoting positive utilities | Dignity/autonomy | Justice/fairness |
|---|---|---|---|---|
| **Industry** | | | | |
| Positive effect | Reduced fluctuation in supply of cotton due to fewer infestations (decrease in negative utilities) | Increased and assured domestic supply of cotton fibers, cotton-seed oil and seed meal (increase in positive utilities) | Freedom to adopt or not to adopt | Fairness in trade due to advantage of GE crops |
| Negative effect | Potential royalty loss from sale of illegal seeds (increase in negative utilities) | Decrease in quality with some engineered varieties (decrease in positive utilities) | Losses through consumer resistance to GE crops | Export rejection due to GE origin |
| **Producers (farmers)** | | | | |
| Positive effect | Reduced cost of pesticides (decrease in negative utilities) | Optimal cotton production (increase in positive utilities) | Freedom to adopt or not to adopt | Fairness in trade due to advantage of GE crops |
| Negative effect | Crop loss from decrease in quality of some GE varieties (increase in negative utilities) | Payment of high royalties (decrease in positive utilities) | Inability to save seed | Price decrease due to large supply |
| **Consumers** | | | | |
| Positive effect | Reduced environmental pollution from decreased use of pesticides (decrease in negative utilities) | Improved environmental quality (increase in positive utilities) | Respect for consumer choice (labeling) | General affordability of product |
| Negative effect | Toxicity or allergenicity of oil and cotton dust (increase in negative utilities) | Immunological reactions to oil and fiber quality (decrease in positive utilities) | Unpackaged sale in market | Higher prices due to patented seeds |
| **Animals** | | | | |
| Positive effect | Reduced pesticide residues in oilmeal feed(decrease in negative utilities) | Improved fodder quality (increase in positive utilities) | Respect for animal feed and health | Availability of nutritious food |
| Negative effect | Toxicity or allergenicity of oilseed meal (increase in negative utilities) | Immunological reactions to feed quality (decrease in positive utilities) | Animals used as test models | Unbalanced diet from excess seed meal in feed |
| **Biota** | | | | |
| Positive effect | Reduced air and water pollution from pesticides (decrease in negative utilities) | Increasing sustainability and reducing pollution (increase in positive utilities) | Maintenance of biodiversity | No additional strain on regional natural resources |
| Negative effect | Allergenicity of cotton fiber and dust (increase in negative utilities) | Increased threat of gene-flow quality (decrease in positive utilities) | Change in population dynamics of lepidopterans | Selective adaptive pressure on lepidopterans and non-target organisms |

*Source:* Adapted from FAO (2004)
*Notes:* Not all items are implemented in India (consumer labeling). This table illustrates the possibilities.
The shaded boxes indicate areas of significant overlap with risk assessment for health and environmental hazards.

Over the last few decades, some food chain operators have been confronted by the public, NGOs and governments over various concerns, including the externalities the contemporary food supply chains are causing, especially in terms of health (Barling, 2007). There is increasing pressure on multi-national food companies to be aware of triple bottom line principles and the need to address social and environmental issues. This has led to more corporations becoming involved in corporate social responsibility so a *Corporate Moral Responsibility Kit* has been developed (http://www.ethicaltools.info). The aim of this is to develop a mutual understanding of the concerns, values, interests and differences between corporations and stakeholders. Some companies such as Unilever have conducted work on how to achieve agricultural sustainability and assist local communities (Pretty et al., 2008). There are still ethical concerns in many other areas, for example, the self-regulatory approach to food advertising used in many Western countries such as the USA, Australia and New Zealand who are responsible for developing and implementing their codes of practice (Hoek and King, 2008).

## Can TA be useful for policy-making in Australia?

### How biotechnology policy was introduced and implemented in Canada and Australia

Abergel and Barrett (2002) have outlined the main events that led to the development and rapid implementation of the biotechnology policy in Canada. In 1980, the Canadian federal government published *Biotechnology in Canada*, which outlined the current areas of research being undertaken in the field of biotechnology. It highlighted the potential opportunities of developing new plant varieties and promoted more research with the aim of maintaining a competitive position in the global marketplace. In 1983, $22 million was allocated for a two year period to establish and implement the first National Biotechnology Strategy; and a further $100 million was used to fund biotechnology research centres. A new National Biotechnology Advisory Committee (NBAC) was established to advise the Ministry of State for Science and Technology (MOSST) on progress and to maximise technology transfer from universities to industry and strengthen science and technology networks and capabilities. The Canadian federal government has approved over 30 GM crop varieties since 1996 and approximately 45 million hectares have been planted since, making Canada the world's third largest user of GM crops (Abergel and Barrett, 2002).

According to Abergel and Barrett (2002), the assumption by the Canadian government was that GM products are essentially no different from crops bred by traditional plant breeding methods and they were sold on the premise that they would deliver economic and other benefits. They suggest that this backdrop may have limited the capacity of regulatory measures to limit further research and development, despite the emerging concerns surrounding the potential environmental impacts. Consequently, it was not until 1988, ten years after continued support for research and development that MOSST issued a regulatory framework for biotechnology *Biotechnology Regulations: A User's Guide*. There were warnings about potential environmental and health impacts, and recommendations by the NBAC for the need to 'urgently' incorporate known, potential and hypothetical risks (in line with international scientific risk assessment principles) into the regulatory framework. However, the competitive pressure to push forward and commercialise GM crops was reiterated in the policy review published by Agriculture Canada's document, *Growing Together (1989)*.

The Canadian public were not engaged until 1993 after the establishment of the Biotechnology Strategies and Coordination Office. The first consultation was opened with a speech by the assistant deputy minister emphasising the benefits of biotechnology. According to Abergel and Barrett (2002), the consultations escalated social and ethical concerns about the use of GM organisms locally and internationally. The NBAC received written responses from a host of social groups reflecting a wide range of concerns, for example the level of corporate influence over the regulatory process, the adequacy of current scientific knowledge, and the need for labelling and for long-term testing of GM products. This pressure and recommendations from experts led to an increase in government spending to assess the long-term health and environmental impacts. This was undertaken to ensure that proponents and critics participate in constructive dialogue to increase the level of understanding and address social and ethical concerns.

Abergel and Barrett (2002) suggest that a broader framing of the policy problem to expand the philosophical and empirical understanding of the potential risks associated with the technology would have assisted decision-making. They suggest that public engagement should be included during the early stages of policy development, instead of producing a regulatory framework that is purely ‘science-based’ well after research and development was underway. In summary, Abergel and Barrett (2002) suggest that the Canadian biotechnology policy was implemented about 10 years before a regulatory framework was developed, and that the social and ethical issues expressed by the public were not addressed until another 15 years after implementation.

The introduction of GM crops into Canada as outlined above started with a pro-biotechnology policy developed by the government. This is also the case in Australia, where in 2000 the federal government produced *Australian Biotechnology: A National Strategy*, which outlined the government’s vision and support for biotechnology. To assist with its implementation, the government established Biotechnology Australia, whose role was to address the non-regulatory issues of biotechnology. The agency was closed in 2008, and a similar agency was created in the form of the Australian Office of Nanotechnology (which was converted into Enabling Technologies in 2009).

Löfgren and Benner (2003) identified the steps taken to implement biotechnology in Australia. The National Biotechnology Strategy outlined a framework for governments, industry and researchers to work together to develop a strong research foundation in biotechnology aimed at reaping the perceived vast benefits in terms of tackling environmental problems, improving food quality and creating better trees for plantations. The Strategy promoted the production of new biotechnologies based on the perceived need to make Australia competitive in international markets and not get left behind (Mohr, 2002). According to Löfgren and Benner (2003), the company

Ernst and Young were given the semi-official status as policy analyst and evaluator, and reported that approximately $300 million of public money was made available for biotechnology research in 2001. In addition, the biotechnology industry fund made another $40 million available over a three year period as a competitive grant program to fill funding gaps during the proof of concept stage and assist with intellectual property issues (Löfgren and Benner, 2003). Another $46.5 million over a 5 year period was used to establish a Biotechnology Centre of Excellence whose role was to promote the number of biotechnology companies in areas such as genomics and bioinformatics, and assist product commercialisation. CSIRO along with the Cooperative Research Centres, which include industry and public research companies, have been proactive in conducting research in GM technology to modify crops to suit the challenging and variable Australian climate (Morell, 2008).

The regulatory system initiated with the formation of the Genetic Manipulation Advisory Committee (GMAC) was established to oversee GM techniques, but was replaced by the Gene Technology Technical Advisory Committee after the implementation of the Gene Technology Act 2000 and the establishment of the OGTR. After June 2001, the *Gene Technology Act 2000* was introduced. This act outlines the regulatory guidelines for the research and development and the production of gene technology. The federal agency responsible for the regulation of gene technology in Australia is The Office of The Gene Technology Regulator (OGTR), whose responsibilities are set according to the *Gene Technology Act 2000.* A full list of the crops approved for commercialisation can be seen on the OGTR website. The *Gene Technology Act 2000* requires the OGTR to prepare reports for the Minister of Health and Aging regarding the issuing of licences for the release of genetically modified organisms. Three committees were established by the *Gene Technology Act 2000* in June 2001, the Gene Technology Technical Advisory Committee (GTTAC); the Gene Technology Ethics Committee (GTEC); and the Gene Technology Community Consultative Committee (GTCCC). Following the statutory review of the Act in 2005, it was found that there had been considerable overlap between the roles of GTEC and GTCCC and it was recommended that the two committees be combined into one advisory committee, the Gene Technology Ethics and Community Consultative Committee (GTECCC), which was established as a result of the *Gene Technology Amendment Act 2007* and became operational on January 1st 2008.

Australia's three tiered governmental structure consisting of federal, state and local government can be problematic as one level can conflict with the others. With the exception of GM cotton in Queeensland, up to late 2008, in most states Australian farmers have been unable to adopt GM crop technologies even though they had been approved by the federal government because of moratoria imposed by state governments. The moratoria in the states such as New South Wales and Victoria were lifted in November 2008 whilst Tasmania's moratorium remains in place. As explained in Chapter 2, Wickson (2007) has criticised the structure and practice of the regulatory system for GMOs in Australia as scientifically-based risk assessment forms the authority in the decision-making. According to Wickson (2007), the other flaw with this process is that risk assessment and risk management plans (RARMPs) are only available for public comment after the document has already been formed by the OGTR, thus preventing any input into how the problem or alternatives are framed (Wickson, 2007).

The legal system in Australia needs to be ready to address the consequences of 'human error' or inadvertent co-mixing by other factors between GM and GM-free crops. Deakin (2008) has written a critique of the *Gene Technology Act 2000* and believes that there is currently no system to combat regulatory conflict by establishing legally enforceable crop separation distances and a compulsory compensation fund for GM-free and organic farmers. Such a system would minimise the chance of GM-free growers suffering any economic loss in the advent of co-mixing from pollen drift or seed spillage. It is suggested that the precautionary principle be applied in a consistent manner in Australian environmental law and emphasises the need for enhanced public participation to enable an effective regulatory framework so as to uphold the Australian public's confidence (Deakin, 2008).

Schibeci and Harwood (2007) analysed the degree of involvement that the community had during the introduction of Australian biotechnology policy. They concluded that the OGTR and the GTCCC had the potential to initiate and increase community participation in gene technology policy. It was suggested that community involvement could be enhanced if the GTCCC and the GTEC did not take a secondary position behind the Gene Technology Technical Advisory Committee (GTTAC) and that provision should be made in the *Gene Technology Act 2000* that allows for community participation in decision-making (Schibeci et al., 2006).

Some social research has been conducted to address the social and ethical aspects of the Australian publics, which are detailed in Chapter 2. In 1999, the Australian Consumers Association initiated the first Australian consensus conference in Canberra, to ascertain the Australian publics' opinion about GM technology. The opening speech by the Minister for Agriculture, Fisheries and Forestry, the Honourable Mark Vaile, aimed to persuade those present to 'consider the economy'. This was a clear indication of the Government's pro-GM position (Mohr, 2002). Other proponents of gene biotechnology included many farmers, and the biotechnology and food industries. Biotechnology Australia conducted research into the Australian publics acceptance of biotechnology and created an arena for public education (Eureka, 2007). Dietrich and Schibeci (2003) reviewed surveys conducted on GM foods in Australia since 1995. They are critical of the way that 'the public' are not treated as active citizens. Instead they are excluded from participating in the process of government and industrial innovation which has resulted in polarised attitudes like we have seen in the UK. They suggest that Australia needs to develop a process that encompasses deliberative and inclusionary processes (DIPs) of the many 'publics' by using consensus conferences and citizen juries (Dietrich and Schibeci, 2003).

Wynne (2006) refers to the 'deficit model' said to underpin science where it is assumed that provision of more technical knowledge to the public will alleviate concerns and enhance public trust in the institution providing the information. Some authors with economic backgrounds, for example Klerck and Sweeney (2007), are still advocating for more cooperation between government, scientists and the food industry with the aim of fostering communication strategies to increase consumers' objective knowledge of GM technology, reduce their risk perception and encourage acceptance.

## What is the situation in other countries regarding biotechnology policy?

Dryzek et al. (2009) analysed the types of deliberative exercises centred on GM foods that have occurred worldwide. He highlights how governing elites establish 'mini-publics' that are guided through a deliberative process to achieve a recommendation that reflects the convenors' worldviews. The polarised worldviews are described by Dryzek et al. as 'precautionary' or 'promethean'. The former encompasses caution until proof that environmental and human safety can be assured, the later have faith in humans to be able to control complex systems for their own advantage and find technical fixes to any unanticipated problems that arise. Prometheans value material prosperity and decentralised markets to stimulate technological innovation. The predominant worldview expressed by mini-publics (usually in a consensus conference setting) is precautionary (Dryzek et al., 2009) . The deliberative process can be skewed in cases where pro-GM governments are seeking a pro-GM conclusion (Dryzek et al., 2009). A series of five categories were established:

> 1. GM technology is relatively well established.
> 2. GM technology is economically important or has been identified as such by government for the future.
> 3. The key governmental organizers or co-organizers of a deliberative minipublic hope for a pro-GM conclusion
> 4. The main organizers of a deliberative mini-public act so as to skew the proceedings toward a pro-GM conclusion.
> 5. Unreflective public opinion as revealed in opinion surveys accepts GM foods.
>
> The United States and Canada fit conditions 1, 2, and 5. Australia fits conditions 2, 3, and possibly 5. The United Kingdom fits conditions 2 and 3. France fits conditions 3 and to a degree, 4. Switzerland fits condition 2. We then look at Denmark to show that a precautionary mini-public's recommendations can be more acceptable to a state that has managed to weaken the link between economic imperatives and Promethean commitments. The Promethean commitment proved strong and unshakable in the United States and Canada. Elites in France, Australia, Switzerland, and the United Kingdom eventually made some reluctant concessions to reflective public opinion (Dryzek et al., 2009, p268-269).

Across most of Europe, GM crops have failed to become embedded into society for many reasons. In comparison to other countries, there has been a concerted effort to seek the views of the various publics prior to any crops being grown commercially. Many tools that have been used to try and seek public engagement using models such as public debates, citizens' juries, focus groups and consensus conferences. Such events need to be properly organised and adequately funded otherwise such engagement will be seen as tokenistic. The GM nation strategy developed in the UK by the Agricultural and Environmental Biotechnology Commission (AEBC) was an attempt to engage the public through extensive deliberative public engagement. This was undertaken to address the social, political, ethical, environmental, health and safety of potential application of biotechnology relevant to non-food agriculture. Although it has been criticised for being underfunded and tokenistic, at least it was a positive step towards increasing public participation (Poortinga and Pidgeon, 2004). Neglect by regulators and the bioindustry resulted in a legacy of distrust in the UK, however, if the proponents of the GM technology had involved the public during the introduction phase then this may have led to more trust in those who control it (Bruce, 2002). Following the GM Nation exercise, research has been conducted to analyse some of the impacts of public engagement and the impacts on trust in government and policy institutions across different social groups. It has been found that more privileged social groups with higher levels of education are more likely to engage as active citizens and be more influential than other groups. Levels of scepticism were widespread, however, less privileged groups showed a positive correlation between scepticism and trust whereas scepticism undermined trust in more privileged groups (Taylor-Gooby, 2006). Democracy can be compromised in some consultation exercises as they can result in particular groups becoming more empowered and not others. The officially credited independent evaluators of the GM nation concluded that the exercise did not take the heat out of the debate around GM crops. There were many valuable lessons learnt through the process in terms of design and implementation such as the time and budget constraints, and the context of political pressure present during the debate (Horlick-Jones et al., 2006).

Another study that involved 55 focus groups across Europe was conducted to ascertain the perceptions of GMOs among citizens (Marris et al., 2001). The most outstanding observation was the huge gap between the stakeholder's views of the public and the actual views of the public, suggesting that regulators need to be able and willing to take on board the results of public engagement (Marris et al., 2001). In the UK in 1992 the Minister of Agriculture, Fisheries and Food set up the Polkinghorne Committee to examine the ethical concerns for the transfer of human and other animal genes into food products. In addition, the Nuffield Foundation financed the formation of a bioethics council to attempt to forecast public concern and to try and address the former piecemeal approach of previous temporary ad-hoc committees, however there was no formal link to the regulatory procedure (Carr and Levidow, 2000). Perhaps this communication with the public has created more resistance to GM technology as the public are more aware of its presence?

Levidow et al. (2002) examined changes that occurred since the late 1990s among stakeholders participating in the European controversy on GM products, which led to a change in the pattern of interactions between policy-making, industry and civil society after pressure from anti-biotechnology protests blocked GM products in the economic arena (Levidow et al., 2002). They have used a model to demonstrate these changes (Figure 3.1). Model (a) represents the traditional interactions between policy-making, industry and civil society where industry lobbied governments for favourable policies and stakeholders from civil society had little influence. Policy-making during this time was based upon the relations between the scientific, regulatory and political bodies which served the markets in the economic arena. Since 1999, most companies have realised the need to accommodate civil society after anti-biotechnology protests started to undermine the traditional model (a) and led to model (b) with some companies establishing high-level strategic committees to analyse socio-political contexts. Resistance to GM food by consumer and environmental groups blocked GM products from the economic arena and paralysed the political arena (Levidow et al., 2002).

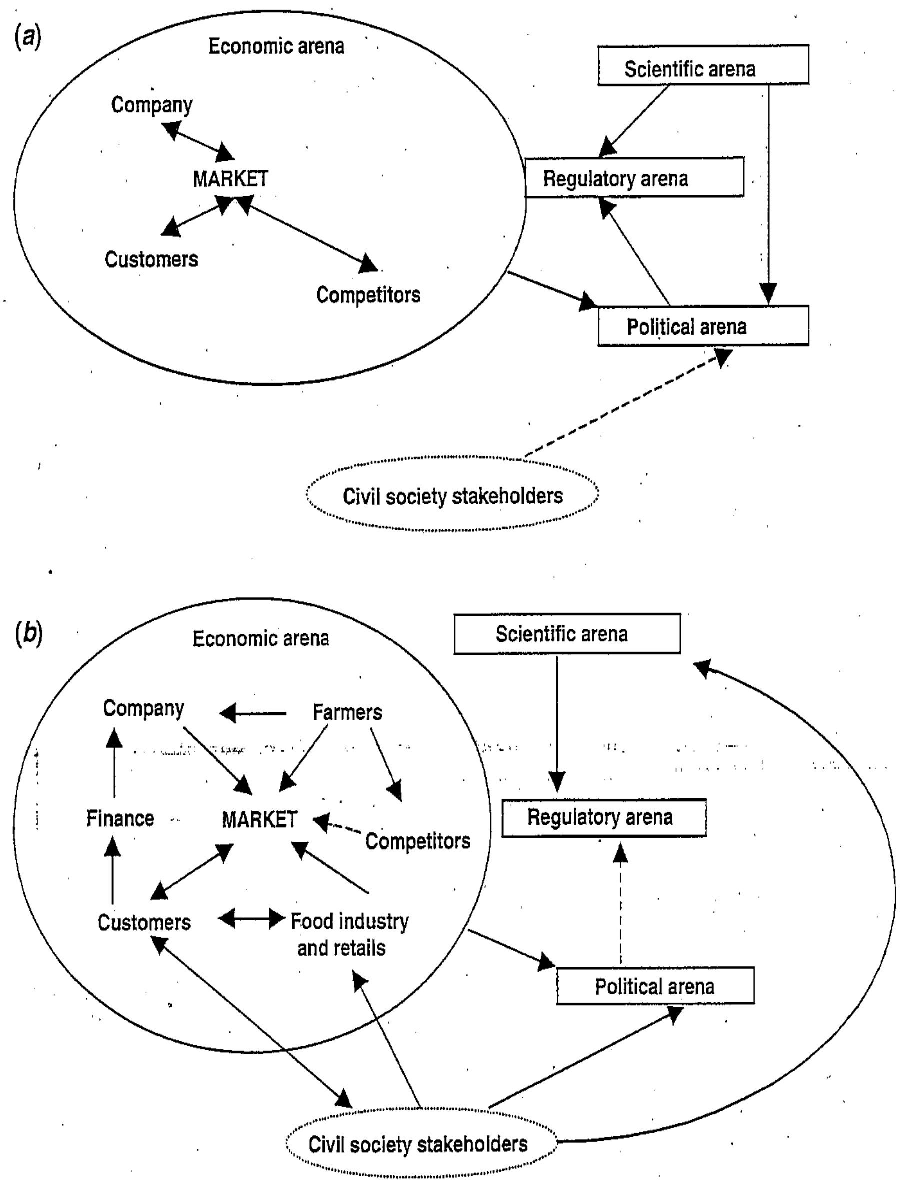


Figure 3.1. Models of relations between policy-making arenas a) Traditional model, b) consumers-as-citizens model.

Source: Levidow et al. 2002

## The future of food in Australia – Can TA be useful?

Can TA be used to form a vision assessment framework to help create a shared vision for food production in Australia? Australia faces many challenges if we are to establish a sustainable food production system which is capable of minimising water use, improving soil structure and fertility whilst reducing undesirable environmental impacts. There are many tools and methods that can be used and each one carries with it different social impacts. Social impacts are often too easily overlooked. According to Burdge and Vanclay (1995, p32), "social impacts include all social and cultural consequences to human populations of any public or private actions that alter the way in which people live, work, play, relate to one another, organise to meet their needs, and generally cope as members of society".

Over the past decade, food and agriculture policy-making in Australia has been fragmented and narrow in its focus often involving the creation of lengthy strategies, and reports which are basically duplicated between various governmental departments. Although a 'paddock to plate' approach is often used to indicate that the proposed strategy is holistic, perhaps this should be extended. In other words, a vision assessment TA process could be used to involve a broad range of stakeholders from the beginning that could inform board members (decision-makers) through to a system of monitoring social impacts. This would also mean involving a broad cross-section of agencies, for example, public health departments and environmental protection agencies and social groups. If a vision can be established, then this may facilitate the implementation of strategies and policies that maximise social outcomes in the future.

Referring again to the concept of technological paradigms, Australia is still locked into a productionist way of thinking as an ideology that is supported by a Fordist (based on an assembly line system of production) food regime. There are strong connections and cooperation between agricultural actors backed by strong government support that promotes agricultural policy focused on production and property rights geared towards profit (Gray and Lawrence, 2001, Bjørkhaug and

Richards, 2008). Agricultural research has been focused upon reducing farm gate prices with the result that environmental and societal impacts are externalised and not included in the final price of agricultural products (Rivera-Ferre, 2008). “Sustainable agriculture has been much less researched than industrial agriculture during the past 40 years, which gives it a considerable margin for improvement” (Rivera-Ferre, 2008 p.1064).

GM technology has been introduced into Australia where it basically fits into the current farming systems where minor changes to, for example, seed and pesticide inputs are required making it easier to incorporate unlike agroecological systems, which are derived from the agronomy and ecology that require a totally different direction (Vanloqueren and Baret, 2009). Genetic engineering can be seen as a high tech technology and somewhat more ‘sexy’ than looking at for instance how effective a mixture of cultivars are against diseases. ‘Genetic engineering’ features a hundred times more than ‘agroecology’ in the top scientific journals (Vanloqueren and Baret, 2009).

There is a range of alternative ways of producing food such as community gardens, organic farming or permaculture that could be used to reduce level of resources currently used in the food industry. There are also alternative ways of purchasing fresh foods direct from the farmer or via farmers markets. There has been very little work to assess what the Australian public’s preferences are regarding food policy. One survey conducted at a large farmers’ market concluded that people wanted policies that would improve information about the food production attributes, for example, the country-of-origin, the use of growth hormones, free range and whether animals were treated humanely, and how environmentally-friendly are the methods used (Umberger et al., 2008). There are many options for debate in many sectors of the food industry including where and how we buy our food. Farmers’ markets, for example, have become very popular over the past 20 years. Over 3,500 have emerged in the US and 450 in the UK, however, Australia has only 70 recognised markets (Umberger et al., 2008).

These alternatives could be incorporated into food and agricultural policy if the public are supportive. Some may see organic agriculture as a more ‘primitive’ way of farming as its ideology does not place economic values first. There is also the perception that organic farming methods result in low yields, however, this has been disputed in recent studies. Badgley et al. (2007) developed a model based upon data from the published literature sourced from 293 studies conducted in the developed and developing world, which compared organic and non-organic production methods. They found that organic production could contribute substantially to the global food supply, and reduce the detrimental environmental impacts associated with conventional agriculture. It was also found that organic methods could produce enough food on a global *per capita* basis to sustain the current (and potentially larger) population on the existing agricultural land base. The results of the model by Badgley et al. (2007) are not intended to as forecasts of global production after conversion to organic methods and do not claim that yields by organic methods would be generally higher than yields from green revolution methods. The main point they make is to demonstrate the potential benefits of organic production systems to reduce environmental impacts and create a more sustainable food production and the need for more research in to this area.

The change from conventional to more sustainable agricultural practices may be difficult to achieve in reality. Farmers can be reluctant to adopt new production methods for many reasons, for example, social barriers, land tenure, lack of government incentives or other impediments (Vanclay and Lawrence, 1995, Rodriguez et al., 2009).

Autonomy and the value of a ‘fair go’ are deep-seated values in the Australian culture, which means that all food production methods should be able to co-exist. According to Vanloqueren and Baret (2009), a reorientation of agricultural science and technology is needed so that holistic approaches include alternative food production methods such as agroecology (Vanloqueren and Baret, 2009). This involves practices such as biological control, perennial food-grain crops, heterogeneous cultivar mixtures, agroforestry and habitat management techniques.

The productionist paradigm takes a reductionist view when it comes to the relationship between food and health (Lang and Heasman, 2004). Plant breeding selection criteria in the past have not included attributes that have health promoting qualities. Cultivars have not been selected based upon their nutritious qualities, such as the ability to uptake and sequester micronutrients, which we are now realising are deficient in our diets (White and Broadley, 2009). These changes have increased the problem of malnutrition due to a decrease in particular amino acids, minerals, vitamins and fatty acids in staple crops (Sands et al., 2009).

## The paradox – Health and the value of the food industry

The Australian food and beverage processing industry is the largest manufacturing industry and generates a significant trade surplus that was around $14.3 billion (2.2% of Australia's GDP) with a turnover of $55 billion in 2000-01. The food manufacturing sector employed 225,000 people nationally in horticulture and other food industries (DAFF, 2002), without these jobs many would be unemployed and rural areas would be the hardest hit. However, diet-related disease costs Australia in the order of $2.5 billion per annum due to lost earnings and health-care costs with nutrition ranking alongside the removal of tobacco as being the most important preventative health measure (Catford, 2000). Is there sufficient cooperation between the agricultural and public health sector and a whole range of social groups to deliberate what the future of food production should look like over the next five or ten decades? As with most policies there are winners and losers, the main problem is how to form a framework that can assist policy-makers and reach a balance that maximises social outcomes.

Should new 'techno-fixes' be promoted, for example, functional foods or nutrigenomics? Part of the food 'innovation' that is occurring is the manufacturing of an enormous range of functional foods. These are foods that deliver a health-promoting effect beyond basic nutrition and are intended for a preventative rather than curative function (Castle et al., 2007). Some authors have criticised this technology as such foods may deter the population from eating a well balanced diet in favour of promoting a conflicting message about the relationship between food and health. The concern is that functional foods will detract from the conventional health science idea of ‘food groups’ blurring the traditional distinctions between the groups by adding fish oil to bread or by putting vitamins into confectionary (Holm, 2003). They may also blur the distinction between the functions of food and drugs, in that food is traditionally consumed for nutrition and to satisfy hunger, whereas drugs are consumed for a specific therapeutic purpose (Preston and Lawrence, 1996). This also adds to the confusion between nutrition messages and health.

One method used to deliver particular nutrients is referred to as microencapsulation. This entails using nano-sized particles that, when mixed with certain nutrients through a process of self assembly, form a microcapsule. Nutrients included in this way vary from polyunsaturated fatty acids, vitamins, minerals, prebiotics and probiotics, taurine, phyto-chemicals and antioxidants (Augustin, 2003). Microencapsulation is used as a method of delivery to prevent the fishy taste of fish oil in bread products, and can increase the stability of vitamins.

## Fragmented agriculture, food and health visions in Australia

As mentioned previously, there are many food and agricultural strategies that have been developed over the past decade. As outlined in the *National Food Industry Strategy (2002),* the Australian government states that it is backing innovation in the corporate run food processing sector, which has to ultimately ensure a return to shareholders. This strategy states that more than $1 billion is spent on agricultural and food research and development each year by Australian governments, rural research and development companies (RDCs), universities and the private sector. The *National Food Industry Strategy* was compiled by the Department of Agriculture, Fisheries and Forestry (DAFF) in 2002 with the purpose of strategically positioning the Australian food industry for development and growth in the future.

The Agriculture and Food Policy Reference Group (AFPRG) was established in March 2005 to review policies and develop recommendations for improving the profitability, competitiveness and sustainability of the Australian agriculture and food sector over the next 10 to 15 years (AFPRG, 2006). Throughout the report there is no definition of sustainability leaving one to wade through it to try and ascertain a meaning. This group consisted of three women, the Chairman of Mrs Crocket's Kitchen, a rural financial counsellor and a representative of Fruitful Enterprises. The other eight male members were from the National Farmers Federation, the Australian Water Commission, the Australian Food and Grocery Council, Landcare, the Kondinin Group, Quarantine and Exports Advisory Council and a farmer representative. Curiously, there are no representatives from the health authorities that are trying to combat diet-related health problems, or any representatives from other social groups. The report they produced was *Creating our Future: Agriculture and Food Policy for the Next Generation* (AFPRG, 2006). The report is structured into four main sections beginning with an introduction that advocates a paddock to plate approach, the liberal ideology of self-reliance, but where partnership and cooperation between industry and government will work towards the sector's 'viability and sustainability' in an environment of reduced regulation. These they have coined as the 'foundations for success'.

There are strategies written by various public health groups including *Eat Well Australia: An Agenda for Action for Public Health Nutrition (2001)*. This was written by the Strategic Inter-Governmental Nutrition Alliance (SIGNAL). This strategy works towards improving the health of Australians but is limited by its focus on nutrition, and has not addressed some of the important issues needed to balance any conflicting interests between the food industry and public health. For example, what manufacturers are able to state about potential health claims of products, or the potential benefits and problems associated with functional foods, or whether foods produced using genetic modification pose other nutritional issues that need consideration (SIGNAL, 2001).

An excellent more holistic (and refreshingly short) report has been published by the Public Health Association Australia, *A Future for Food (2009)*. This also refers to a ‘paddock to the plate’ approach, but encompasses the social and environmental issues such as sustainable food choice that can be enhanced by eating locally produced fresh wholefoods, and mentions the return of deficiency diseases and the concern over equity. It also refers to water usage, green house gas emissions, food security and waste (PHAA, 2009). It states that the National Preventative Taskforce reported that the overall cost of obesity to Australian governments and society in 2008 was $58.2 billion. It concludes (p12) that “ultimately, food policy cannot put the interests of industry ahead, or indeed even alongside, the interests of individuals, their communities or the planet”. The report calls for a new Australian food policy framework involving a cross-government approach that actively promotes health and prevents chronic diseases especially in high risk groups. This should be based on food choices that are environmentally sustainable and conducive to Australian social and cultural practices.

Yeatman (2008) from the School of Health Sciences at the University of Wollongong is also critical of the current food and nutrition policies. She states that the lack of public engagement and government transparency in food policy debates has increased since the creation of FSANZ. FSANZ has stated its commitment towards community involvement and that it recognises that community involvement is a two-way process (http://www.foodstandards.gov.au/foodstandards/changing the code/information for applicants/communityinvolvement3610.cfm). As is evident from their website, FSANZ does publish information about proposed changes to food standards under development and informing the community about the processes and issues pertinent to each application and proposal. They ask for comments on each application and proposal, either as formal submissions on assessment reports or through participation at stakeholder forums. However, there is no information about the process used to assess the information collected for decision-making.

Yeatman (2008) suggests that the Second European Action Plan for Food and Nutrition Policy (2007-2012) developed by the World Health Organisation be used as a template for Australia (Yeatman, 2008b). This plan emphasises the need for a whole-of-government approach to formulate comprehensive food and nutrition policy. The need for this has also been reiterated in a review by Sacks et al. (2008) who analysed the policy areas that influence the food system and physical activity environments in the Australian context (Sacks et al., 2008).

The First WHO European Action Plan (2000-2005) provided a diagrammatic framework of the policy and institutional interactions needed to improve health (Figure 3.2). This includes creating a strategic plan that is communicated and implemented across the entire food industry, and supported by regulatory instruments. The conduct of health impact assessment of food-related policy would facilitate ongoing learning for the development and refinement of future policies. Many countries have initiated food and nutrition action plans. To date, only limited work has been conducted to assess some of the current problems that stand in the way of this happening in Australia. Surveys have shown, for example, that there are considerable differences in the level of activity and engagement that local governments have in food and nutrition activities in different states across Australia (Yeatman, 2008a). More research is needed to identify current problems before any new food and health policies can be implemented in Australia.

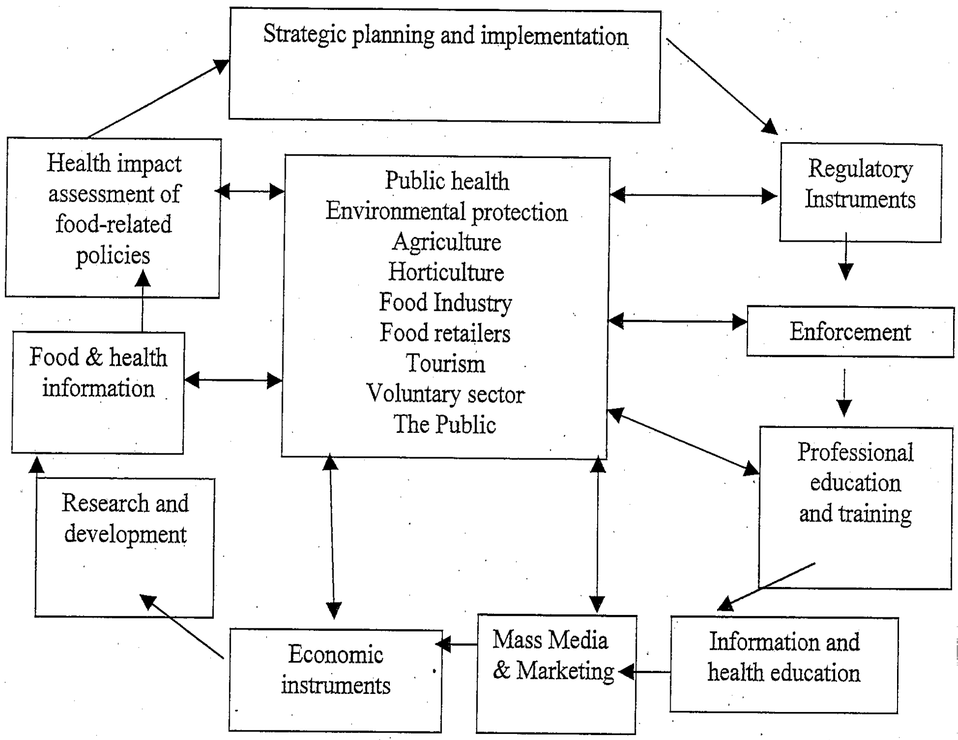


Figure 3.2: An Integrated Approach to food, nutrition and health

Source: First Action Plan for Food and Nutrition Policy, European Region of WHO, 2000-2005 Copenhagen: WHO Regional Office for Europe.

## Conclusion

Technology is a social practice which profoundly impacts upon people's lives. There is no single definition of technology; however, different approaches can provide a deeper understanding of the concept. The approaches of SCOT and technological paradigms can be useful to help policy-makers, scientists and industrialists understand the relationships between stakeholders and how they affect innovation processes. There are issues associated with technology which can cause conflicting emotions of anxiety and fear, or wonder and curiosity (Mordini, 2007). This may due to concerns about who controls it, or which social groups hold the greatest power and influence in the decision-making processes about which technologies are created.

A framework referred to as technology assessment (TA) was developed initially in the US to inform legislators about issues arising from science and technology during the early 1970s. Technology assessment has evolved into many different types which have various attributes which include a broader range of stakeholders, who have a greater influence in what and how technologies are developed. The aim of TA is to facilitate learning and communication between social groups that may be directly or indirectly affected by a new development, so that the social or political context can be changed if necessary to maximise social outcomes. TA can be used as a forecasting tool to predict what *probable* impacts may occur, or it can be used as a framework for vision assessment to analyse *possible* future options and utopias.

A TA framework may have been beneficial to address the social, ethical and legal aspects that were intrinsic to the development and implementation of Biotechnology Policy. Australian GM crop biotechnology has been developed and implemented in a similar way to Canadian GM biotechnology, and similar mistakes have been made. Neither country addressed the views of their publics during the early stages of the policy-making process or during the research and development stage. Despite social research conducted by Biotechnology Australia showing that there is a lack of knowledge about the current use of biotechnology in Australia in general (Eureka, 2007), commercialisation of GM technologies has occurred. Subsequent social research that has been conducted basically amounts to being post-market research. The governments of both countries assisted in the promotion and implementation of their biotechnology policies by providing substantial funding. Canada failed to establish a regulatory framework until 10 years after the strategy was published; Australia still has gaps in the regulatory system.

An interactive TA exercise was conducted by the scientific institute, INRA, to address the potential social and ethical issues that were anticipated during the introduction of GM grapes in France. The main conclusion was that public participation should have taken place early in the policy-making process to enable the development of the technology to change course (Joly and Rip, 2007). A negative outcome was that

INRA were suspected of manipulating public opinion. To minimise the risk of increasing suspicion and reducing the level of trust that the publics have about certain actors or agencies (the more powerful or 'expert' they are, potentially, the higher the risk may be), it is proposed that better outcomes may be achieved if the TA is undertaken by an independent TA identity.

It has been proposed that a TA vision assessment framework may be useful to help create a shared vision for the future of food in Australia, which involves a broad range of social groups involved throughout the food-chain. The aim of this would be to debate alternatives for the production, processing, retailing, consumption and subsequent health monitoring, to achieve a sustainable future for food. To date, there are many fragmented food, agriculture and health strategies in Australia from various government departments. The WHO have a template to assist with the development of an integrated food, nutrition and health policy which involves a whole of government approach and many publics. The current model for decision-making for food and agricultural research has been criticised because it only includes stakeholders from industry and the scientific community. It is suggested that this be broadened to include the subjective and objective views of numerous social groups in the food policy-making process.

# Chapter 4 – Evaluating the potential of Technology Assessment (TA) utilising the CSIRO Food Futures Flagship omega-3 project

## The Technology in Social Context (TASC) project

This PhD was a component of an overarching ARC Discovery project – Technology Assessment in Social Context (TASC) (Russell et al., 2010). TASC was a collaborative project between Prof Frank Vanclay located at the Tasmanian Institute of Agricultural Research (TIAR) at the University of Tasmania, Dr Wendy Russell previously at the University of Wollongong, and Dr Heather Aslin now at the Charles Darwin University (and previously with the Bureau of Rural Sciences). The aim of the TASC project was to develop a framework for technology assessment that would be effective in the Australian context and to devise a form of TA which focused on the social context (Russell et al., 2010). A case study was established to pilot the emerging TASC framework. The proposed TASC framework developed by Russell, Vanclay and Aslin consists of a stepped process of:

- Scouting – identifying emerging technological developments in the pipeline.
- Screening – selecting and prioritising technologies for assessment based upon criteria such as its potential to have a high social impact (magnitude and distribution), where outcomes may be uncertain, or where there is likely to be community concern.
- Scoping – conducting a preliminary assessment to frame the topic, its purpose, the methods that should be used, stakeholders and resources needed.
- Assessment – of the potential social consequences associated to a particular technology.
- Communication and participation – Facilitating multi-way communication between all stakeholders.
- Evaluation – reflection on the process, methods, content and outcomes (ongoing learning).

New emerging technologies were identified in the scouting stage of the TA and included, for example, the use of nanotechnology in the food industry, virus control of carp using koi herpesvirus and GM poppies. The screening process resulted in the selection of the CSIRO Food Futures Flagship omega-3 project as a case study as this was still in the research and development phase and was likely to have widespread benefits due to the improvements to human health, and the potential to reduce pressure on existing seafood stocks. There could be more adverse social consequences if this technology failed to become accepted and embedded into society. The willingness of the omega-3 project team to be involved in the study was also an important consideration.

The TA for the case study of omega-3 was undertaken by conducting 30 interviews and 6 focus groups with a range of stakeholders. Initially, it was intended that a constructive TA process would be used to facilitate communication between the CSIRO scientists and particular social groups that may be affected by the technology. The other main aim of the TA was to increase the awareness of the CSIRO scientists to the social consequences of their work and encourage them to be reflexive about any issues that may have arisen. This will be achieved by reporting the results of the fieldwork to the CSIRO scientists.

## Overview of the CSIRO omega-3 project

Long-chain fatty acids can be defined as containing 20 or more carbon atoms in the molecule (Nichols, 2004). The main aim of the CSIRO omega-3 project is to produce a sustainable land plant-based source of omega-3 long-chain polyunsaturated fatty acids ($\omega$3 LC-PUFA) to supplement current fish oil sources (Nichols, 2004, Nichols, 2007). These are also referred to as long-chain omega-3 oils, which will be the term generally used in the thesis. Currently fish oil used in aquaculture feeds and for human consumption is obtained by harvesting wild fish stocks which are in decline (Pauly et al., 2005). This project would reduce the pressure on wild fish stocks by developing a sustainable source of long-chain omega-3 oils.

There is an increasing body of evidence that consuming long-chain omega-3 oils improves the health and well-being of human and animal populations (Ruxton, 2007). The product from the omega-3 project would increase the quantity of long-chain omega-3 oils available for consumption.

The trade in world fish oil and fishmeal totals approximately 4 million tonnes, of which nearly 90 percent consists of fishmeal (Nichols, 2007). The Food and Agriculture Organisation of the United Nations (FAO) reviewed the future of marine capture fisheries. They highlight the complexity of forecasting the future sustainability of fisheries due to the numerous political, social and economic variables that impact upon it over time (Garcia and Grainger, 2005). During the 1970s and 1980s, new fishing technologies and increased investment in the fishing industry and an expansion of fishing fleets contributed to an increase in wild fish capture from 44 million tons in 1973 to 65 million tons in 1997 (Delgado et al., 2003). One-quarter of marine fish and organisms were discarded globally by wild-fishing operations. Some methods used to harvest fish are particularly harmful to the environment and result in the destruction of marine habitats and depletion of some species that get caught up in the fishing process, for example albatross and dolphins. Concerns about the future sustainability of wild fish stocks underlined the CSIRO objective to find an alternative sustainable source of long-chain omega-3 oils (Nichols, 2004, Nichols, 2007).

Other benefits of a land plant-based source of omega-3 include the fact that there is concern that fish, especially large predatory species, may contain undesirable levels of mercury and other contaminants including various organochlorines (Domingo, 2007, Mozaffarian and Rimm, 2006). Some people are also unable to or don’t like eating fish and shellfish, and others are allergic to seafood. The technology being developed by CSIRO would provide an uncontaminated product that would not cause an allergic reaction. People who choose to be vegetarian currently ingest particularly low levels of long-chain omega-3 oils (Mann et al., 2006), may particularly benefit from a land plant-based source of long-chain omega-3 oils.

There are two main ways in which the oil can be consumed; either directly in capsules or in functional foods and spreads, or indirectly by incorporating it into livestock feeds to increase the long-chain omega-3 oils content of farmed fish, beef, eggs and other wholefoods which are then consumed by humans. If either method is used, then quantities of long-chain omega-3 oils consumed may be increased if the cost of the oil is not significantly more than fish oil, which could make it affordable to all socio-economic groups.

To date, scientists from the CSIRO have successfully inserted a set of genes that encode for desaturase and elongase enzymes into rockcress (*Arabidopsis thaliana*) allowing it to synthesise long-chain omega-3 oils from their $C_{18}$ PUFA precursors resulting in the production of seed-based oil containing either docosahexaenoic acid (DHA) and/or eicosapentaenoic acid (EPA) (The structure and biochemistry of these fatty acids will be explained in more detail in the next section of this chapter). This was achieved by the sequential transformation with two binary vectors containing an 'EPA construct' that enabled the conversion of α-linolenic acid (ALA) to EPA and linoleic acid (LA) to arachidonic acid (ARA) followed by a second DHA construct for the necessary enzymes to convert EPA to DHA (Robert et al., 2005). The next stage is to insert the necessary enzymes into oilseeds such as canola, cotton, linseed or sunflower and potentially cereal crops.

It is intended that a large biotechnology company will eventually take ownership of the patent or license for any subsequent seed that would be distributed for sale in the same way as other GM crops on the market. The aim, after the necessary regulatory procedures have been successfully completed, is to grow commercial quantities of the crop. There are some challenges that are unique to obtaining long-chain omega-3 oils as opposed to the conventional land plant-produced short-chain (containing less than 20 carbon atoms in the molecule) omega-3s. The harvested oil is likely to be less stable than conventional oils from crop plants and may require extra care during the processing stage to minimise oxidation. After the oil has been extracted, purified and packaged ready for sale, it can be marketed and used in two different ways, either directly by placing it into capsules or incorporating it into a range of food products, or indirectly by feeding it to livestock or fish as mentioned earlier.

## Review of essential omega-3 fatty acids

### Chemical structure of fatty acids

The majority of natural fatty acids are comprised of linear hydrocarbon chains ranging in length from 2 to 80 carbon atoms and have an acid group at one end and usually a methyl group at the other (Jones, 1997). Fatty acids are separated into a number of groups such as saturated (SFA), monosaturated (MUFA) and polyunsaturated (PUFA). SFA such as stearic acid do not contain any double bonds in the carbon chain unlike the other two groups. The position of the double bond in relation to the methyl end denotes the series of the unsaturated acids. Naturally occurring unsaturated acids fall into three major groups, the ω3, ω6 and ω9. PUFA include two groups; the omega-3 and omega-6 series.

Fatty acids are identified by a common name and biochemical abbreviation. For example, DHA has the biochemical abbreviation of 22:6 ω3. This depicts the molecule as having 22 carbon atoms in its chain, 6 of which contain unsaturated bonds. The ω3 depicts the position of the first double bond as being on the third carbon atom from the methyl end of the molecule. Animals including humans are unable to synthesise either of these nutrients in the body and must acquire them in their diet, hence they are termed 'essential' fatty acids.

### Function of essential fatty acids

The importance of dietary long-chain (containing more than 20 carbon atoms in the molecule) omega-3 oils was initially highlighted from studies undertaken on the Greenland Eskimos in 1976, whose diet consisted of large quantities of marine animals and was correlated to their low rates of cardio-vascular disease despite the consumption of high fat levels overall (Bang et al., 1980). Since then, there is a growing body of evidence suggesting that these nutrients have many health benefits. Long-chain omega-3 oils such as DHA have beneficial effects against lifestyle diseases such as cardiovascular disease, stroke, cognitive disorders, asthma and diabetes, and are beneficial in infant and retina development (Lauritzen et al., 2001, Wongcharoen and Chattipakorn, 2005, Ruxton, 2007, Harris, 2007, Sinclair et al., 2007).

Fatty acids are the building blocks of lipids such as phospholipids, glycolipids, sphingolipids, sterol esters and triacylglycerols (Jones, 1997). The principal role of fatty acids is to provide a source of carbon atoms and energy and a range of other functions both structural and physiological and pathophysiological. Deficiency of ω6 fatty acids can manifest itself in symptoms such as dermatitis, growth retardation and infertility and reflect their biological function (Lauritzen et al., 2001). Unsaturated acids are essential in maintaining the fluidity and structure of phospholipid membranes. Linoleic acid is present in long-chain ceramides that act as a water barrier in the skin (Jones, 1997). Increasing evidence suggests that ω3 fatty acids such as DHA have a specific role in membrane function in the heart, brain, retina and sperm and are involved in altering gene expression. If cell membranes are not intact, DNA can be attacked by free radicals, which can result in mutation and subsequent cancer growth. Dietary ω3 and ω6 acids are able to influence the rate of cell division of cancer cells and of the immune response (Gleissman et al., 2010). These acids are also the precursors of eicosanoids, hormone-like substances that have major health effects.

The major organ involved in fatty acid metabolism is the liver, although it does take place in other tissues. The two PUFA groups (ω3 and ω6) go through two transformations in the endoplasmic reticulum that involve desaturation, whereby two hydrogen atoms are lost and elongation resulting in an increase in the number of double bonds. The ω6 PUFA LA found in sunflower, corn and safflower is converted to ALA, which is also present in borage and evening primrose. This is subsequently converted to ARA also found in meat, and then into ω6 eicosanoids. The ω3 PUFA ALA found in crops such as flaxseed and canola is converted to EPA a nutrient present in fish oil. EPA is then converted into DHA, which is also found in fish oil and to ω3 eicosanoids (Simopoulos and Robinson, 1998). Fish do not synthesise long-chain omega-3 oils, which is produced by marine micro-algae such as Thraustochytrids (Lewis et al., 1999), other micro-algae and bacteria and passed up the food chain where it becomes incorporated into body tissues.

It has been demonstrated that there is competition for the same enzymes by both ω3 and ω6 PUFA during the synthesis of the respective long-chain PUFA (Lauritzen et al., 2001). Studies on animals have shown that ALA is a strong suppressor of ω6 metabolism rather than the contrary (Lauritzen et al., 2001). EPA is involved in the regulation of eicosanoid production from ARA. The production of ω6 eicosanoids can therefore be inhibited by the consumption of ω3. The role of EPA or rather its metabolites, is considered to be functional, whereas DHA has a structural role (Gunstone, 2007).

## Sources and levels of intake of long-chain omega-3 oils

The recommended intake and actual consumption of long-chain omega-3 oils varies considerably from country to country. The American target intake of long-chain omega-3 oils is 500 mg increasing to at least 800 to 1000 mg/day for people with underlying overt cardiovascular disease (Lavie et al., 2009). French recommendations for long-chain omega-3 oils are 500 mg/day (including 120 mg/day of DHA) for men and 400 mg/day (including 100 mg/day of DHA) for women (Astorg et al., 2004), whilst an expert committee in the Netherlands suggests a minimum intake of 200mg/day (de Deckere et al., 1998). The Scientific Advisory Committee on Nutrition and Committee on Toxicology in the UK recommend 450 mg/day of EPA and DHA, however intake in the UK averages 244 mg/day and falls to 113 mg/day if the 27 percent of people who consume oily fish are excluded (SACN/COT, 2004). Within Australia, it is generally agreed that 500 mg/day of long-chain omega-3 oils should be consumed, however, the average daily intake is estimated to be between 100-200 mg per day (Nichols et al., 2010).

The American Dietetic Association and the Dietitians of Canada recommend that adults should consume 20 to 35 percent of their total energy requirement from fats and reduce intakes of saturated and trans-fatty acids and aim to increase the long-chain omega-3 oils from a range of sources such as vegetables, fruits, nuts and seeds, lean meats and especially oily fish together with non-hydrogenated margarines and oils (ADA, 2007). The main dietary intake of PUFA is in the form of the 18 carbon ω6 LA and ω3 ALA. Biosynthesis of long-chain omega-3 oils from the shorter chain ALA is very low in humans. The reported efficiency of conversion in humans and animals varies considerably as does the efficiency of different tissue types. The ability of humans to convert ALA to EPA and DHA *in vivo* is poor especially in men (Givens and Gibbs, 2006).

Fish have always been regarded as a nutritious source of food as they are a source of protein, vitamins A, B and D, calcium, phosphorus and microelements such as selenium, iodine and fluorine, and lipids (i.e. fats and oils) (Kolakowska and Olley, 2003). The lipids in particular have received attention and have been deemed as being helpful towards numerous health related ailments. Triacylglycerols are the predominant form of lipid found in oily fish, followed by phospolipids and sterols. Fish vary in their fat content and the major lipid storage sites vary in different species. Most lipids are located in the subcutaneous tissue and the amount of lipid dispersed through the flesh can decrease from head to tail (Kolakowska and Olley, 2003). The quantity of long-chain omega-3 oils incorporated equivocates to the concentration of the nutrient that is incorporated into body tissues (Givens and Gibbs, 2006). Farmed fish can often be deficient in long-chain omega-3 oils if they are fed low quantities of it, which can occur when vegetable oils are used as a substitute for marine lipids in aquafeeds (Nichols et al., 2002, Nichols et al., 2010).

## Direct Uses: Micro-encapsulation into food products and fish oil capsules

The potential oil from the CSIRO omega-3 land plant-based source could be used as a direct replacement for fish oil. It could be placed into capsules or micro-encapsulated and incorporated into functional foods. Foods that offer health benefits above and beyond their basic nutrition are referred to as functional foods (IFT, 2005). Within Australia, the company Nu-Mega (owned by Clover Corp) was one of the first companies to produce and incorporate tuna oil in a microencapsulated form for use in a wide range of everyday food and beverages (Hjaltson and Haraldsson, 2007). Their first application was infant formula. The advantage of microencapsulation is that there is no fishy taste. Another product manufactured by George Weston Foods Ltd is omega-3 enriched bread marketed as ‘Up’. Other enriched foods and beverages available include orange juice, milk, yoghurts and cakes. Micro-encapsulation is used to prevent oxidation of the oil, which can affect the taste and smell of food. Fishy odours and taints arise from organoleptic compounds, which can form hydrogen sulphides and mercaptans due to oxidative processes during storage (Kolakowska and Olley, 2003).

## Indirect incorporation into livestock and aquaculture products

The potential mean intake of EPA and DHA by humans could be increased if animals are fed feeds enriched with fish oil and fish meal. In animals the conversion rate varies according to the species and the genotype. Monogastric animals are more efficient than ruminants at transferring long-chain omega-3 oils into their flesh and other consumable products. Ruminal metabolism causes biohydrogenation of PUFA and reduces the fatty acid concentration in muscle, however, there are still positive effects on human health especially if tissue supply is increased directly (Sinclair, 2007). Incorporation of long-chain omega-3 oils into animal flesh and especially milk is low and is considered by some to be unsustainable in the future (Rymer et al., 2003). However, there are other technologies being developed to improve the efficacy of transferring long-chain omega-3 oils into animal products. Tuna oil fed to ruminants can be protected from ruminal biohydrogenation using, for example, a casein-formaldehyde matrix (Kitessa et al., 2001a, Kitessa et al., 2001b).

Studies have shown that there is no relationship between dietary short-chain content and long-chain omega-3 levels in poultry, so if conversion does occur, long-chain fatty acids are not deposited in edible tissues (Rymer and Givens, 2006). Feeding chickens high levels of short-chain ALA in an attempt to increase the formation of EPA and DHA is not an effective substitute to feeding long-chain PUFA (Leskanich and Noble, 1997). Chickens fed with fish oil had raised levels of long-chain omega-3 oils present in their flesh. It was estimated that 100 g of fat modified chicken meat provides 142 mg of EPA+DPA+DHA, and in comparison the same sized portion of cod flesh contains 138 mg (Hulan et al., 1989). It is possible to provide a dietary intake of 230 mg/person/day with poultry meat as the largest source (Givens et al., 2006). As with direct uses, there is also concern about the oxidative stability, sensory and storage qualities of enriched meat and eggs. Fishy odours occur from a range of compounds with both lipid and non-lipid sources leading to an unpleasant taste and a rancid smell, however, there are methods of overcoming these problems. When more than 1.5 % concentration of fish oil was added to feeds for chickens, it was enough to cause egg tainting, however, this could be minimised by keeping concentrations below this level and by enriching the egg yolk with antioxidants (Sparks, 2006).

The transfer of long-chain omega-3 oils into the flesh of fish fed in the aquaculture industry varies considerably according to species. Australian farmed salmon is an extremely good source of long-chain omega-3 oils. Tasmanian Atlantic salmon from southern waters, and barramundi from northern waters, provide up to 10 times more LC omega-3 (~3,000 mg/150g) than the average wild fish (Nichols et al., 2002), although when fish oil is substituted in part by non-marine oils, lower content occurs (Nichols et al., 2010).

## Review of social research conducted on GM foods and GM long-chain omega-3 oils in Australia

Consumer research predominantly based upon results from surveys has been undertaken to ascertain perceptions of risk to food biotechnology in Australia (Cormick, 2003). A report compiled for the Rural Industries Research and Development Corporation (2005) surveyed Australians about their perceptions of GM foods, and the level of knowledge and confidence in organisations responsible for the distribution and regulation of GM foods (Owen et al., 2005). They found that people would avoid or reduce their likelihood of purchasing GM products that had no perceived benefits, even if products only contained a trace amount. Owen et al. (2005) recommended that more research be conducted in this area, particularly those with real consumer benefits as the commercialisation of some GM foods was deemed unviable. They also found that concerns over GM did not rank highly among other everyday consumer concerns and that consumers usually make daily purchases with minimal information.

A longitudinal study commissioned by Biotechnology Australia sought to gain a greater understanding of what people think about GM technology using quantitative and some limited qualitative methods (Eureka, 2007). Overall, it was found that between 2005 and 2007 there was a significant increase in the awareness of and support for GM technology due to numerous factors. However, this finding may be questionable due to differing sampling methods and sizes used each year.

The other conclusion in this report was that there was more support for GM applications to improve health than there was for use in food and agriculture, which was associated with commercial objectives. The majority of participants (55 percent) thought that the use of GM in agriculture was mostly for the benefit of companies. There were a minority of people who were strongly opposed to GM (a similar number as those who were strongly in favour) due to attitudes and beliefs related to industrial food production, and potential adverse effects on human health and environmental impacts (Eureka, 2007). Many people in their focus groups expressed concern about widespread plantings of GM crops due to the potential irreversible environmental impacts and the ‘contamination of the food-chain’. Some in their focus groups thought that that there is not enough evidence to support that GM crops are completely safe, and that effects on human health should be ‘unequivocally established’ with participants advocating the need for research to be conducted over many years (Eureka, 2007).

Some 54 percent of the Biotechnology Australia participants thought that modifying the genes of plants to produce food was ‘risky’. Some 76 percent perceived this technique as being ‘acceptable’, however, this was because it was believed to entail comparatively ‘natural’ methods such as selective breeding rather than ‘unnatural’ GM technology. The majority of participants were more willing to eat organic food (on a scale of 8.7 out of 10) than all other foods including the commonest form of food grown using pesticides (4.6 out of 10) The use of genes sourced from animals was not supported, plant sources were more acceptable. Other issues were that GM products were being purchased inadvertently due to inadequate labelling of GM products, thus, violating their ability to make an informed choice with participants expressing feelings of powerlessness. There is also a widespread misconception about the type of foods that are produced using a GM process (Eureka, 2007).

Quantitative studies have been conducted to ascertain the attitudes of Australians about their willingness to consume long-chain omega-3 oils indirectly via functional foods (Patch et al., 2005a, Patch et al., 2005b, Patch et al., 2005c). One study indicated that dietary intake of long-chain omega-3 oils could be increased by consuming a range of long-chain omega-3 oils in functional foods such as, milk, cereals and bread, however, despite the potential health benefits there was a negative consequence in this particular study as the participants gained weight (Patch et al., 2005a). This has not been the case in other studies. There are a range of long-chain omega-3 oils enhanced products on the market, however some have not been very popular for various reasons, for example, sensory reasons in the case of bread despite microencapsulation to minimise fishy odours and taste (Cox et al., 2007). Another study attempted to understand the complexity of the decision-making process that people experience when choosing to consume long-chain omega-3 oils enriched functional foods, which resulted in marketers of these products being advised to change people’s attitudes and beliefs about the effectiveness of these products (Patch et al., 2005a). Patch et al. (2005c) showed that despite participants being aware of the potential health benefits of long-chain omega-3 oils in functional foods, they were reluctant to consume them due to fears about overdosing, and cost was also a major barrier. There was also scepticism about such products being promoted predominantly as a marketing gimmick, rather than being beneficial for health.

Cox et al. (2007) conducted a study to ascertain the intention of Australian consumers to consume a range of foods containing conventional and GM sourced long-chain omega-3 oils. The findings showed that people were not stimulated to consume GM long-chain omega-3 oils products despite having a propensity for coronary heart disease, or after being informed about the health or its environmental benefits. To acquire the target intake of long-chain omega-3 oils based upon the concentration of fish oil in these products, 10 slices of bread would have to be eaten each day, or a litre of milk (or combinations of the two) to reach the target intake of long-chain omega-3 oils. The authors also reported that a sizable proportion of people were prepared to consume long-chain omega-3 oils from a GM process and that this was particularly the case if the oil was used in fish feeds, in other words in a form not much different from fish fed using non-GM feeds (Cox et al., 2007).

Other studies have endeavoured to explain the process of GM food acceptance in Australia (Mohr et al., 2007). The complex model showed that acceptance or resistance towards GM reflected trust towards scientists and receptiveness to science and technology. Education level was a strong predictor of acceptance of new technologies, which declined with increased education level (Mohr et al., 2007).

## Methods used for the case study

The technology assessment (TA) of the CSIRO Food Futures Flagship Omega-3 project involved two different qualitative methods: (1) key informant interviewees and (2) focus groups, with the results from each being transcribed into a word document and imported into the social research package, NVivo. Ethics approval was applied for and granted by the University of Tasmania (reference H5498). The data from the word documents (data were transcribed in to word files) was coded to address the research questions and identify the main issues that were of direct relevant to CSIRO. Analysis of the word data can be conducted in a number of ways. A word(s), for example ‘GM food’ could be searched resulting in a page summarising all the quotes provided by the participants. The other method is to search for packets of information pertaining to an issue and ‘code’ the information by highlighting it and placing it into a node or tree node. Coding word data results in a ‘packet’ of views expressed by particular social groups. Environmental groups, example, were particularly concerned about a broad range of issues surrounding global food production not just GM technology. Some viewpoints were expressed across a number of social groups. The coding density made it clear which views were frequently expressed. Extensive use of quotation was deliberately included in this chapter to ensure that all of the main views were presented and to provide further insight into why people thought that way about a particular issue. The specific issues that were of direct interest to the CSIRO were included in the later part of this chapter, for example, views about the pros and cons of incorporating long-chain GM omega-3 oils into foods directly or indirectly. This data provided more insight into previous research conducted by other authors discussed in the previous section.

### Interviews

Throughout 2007 and 2008, a total of 30 key informant interviews were undertaken with social commentators from a diverse range of backgrounds and disciplines, as well as with scientists and industry people. This included representatives from the fishing and aquaculture industries, environmental, health and nutrition organisations as well as others involved in the food industry. Potential interviewees were contacted by phone or emailed asking for their willingness and availability to be interviewed. Consent forms were attached to any emails for their information. All interviews except one phone interview were conducted face to face at a location that was convenient to participants.

Semi-structured interview questions for key informants were finalised after a pilot study was conducted on three scientists from the University of Tasmania. The data from these initial interviews was not used in the results. A consent form and information sheet was issued to the participants at the beginning of an interview where two copies were signed by the interviewee and the interviewer; the participant kept one copy whilst the other was collected and stored to comply with University ethical procedures. A digital voice recorder was used to record each interview. Each participant was asked to acknowledge their awareness and consent to being recorded.

A laminated pictorial card identical to the one used in the focus group poster (Figure 4.1) was developed. An overview of the omega-3 project was given to each interviewee explaining that fish are normally the source of long-chain omega-3s (as opposed to short-chain omega-3 found in oilseed plants) and that fish do not synthesise these nutrients but that marine micro-algae are the primary source of long-chain omega-3 which are passed up the food-chain to fish and humans. The CSIRO project involves inserting the genes from micro-algae into oilseed plants such as canola so they can produce the long-chain omega-3. The two potential uses for this oil were outlined. The first use involves incorporating the oil into feeds for use in the aquaculture and livestock industries where it is accumulated into animal tissues. The second method involved direct consumption of the oil by capsules or incorporation into a range of functional foods. After the overview of the omega-3 project was given, semi-structured questions were aimed to investigate:

- Their present knowledge of omega-3 fatty acids.
- Their initial thoughts about the CSIRO omega-3 project, the pros and cons of indirect and direct use of the GM oil.
- Who they thought would benefit and who may be disadvantaged.
- Who else they thought should be contacted for an interview.
- Any issues or general thoughts about the food industry.
- Their current awareness and understanding of technology assessment and their thoughts about its usefulness and application in the food industry.

### Focus groups

Six focus groups were held, three in Hobart, Tasmania and three in Melbourne, Victoria. The purpose of these group sessions was to flesh out any other thoughts and feelings that may be expressed in a group environment where interaction and active discussion were encouraged. The first group composed six scientists from the Tasmanian Institute of Agricultural Research at the University of Tasmania, which served as a pilot study group. The University of the Third Age (U3A) in Tasmania formed a group consisting of eight people. U3A members consist of retirees who meet on a regular basis to engage in various activities. As the interviews indicated that there were potential concerns and issues raised by health professionals, a group of four medicos was sought from the University of Tasmania’s School of Medicine to explore these further. An email was sent around the school asking for volunteers. The opportunity to hold a focus group with the Victorian Grains Council at the Victorian Farmer's Federation building presented itself as it coincided with their routine meeting and consisted of fifteen farmers from around the state. Although it is not ideal to have a focus group this large, this group were a very disciplined in that they put their hands up if they wanted to say something. Jeanette Hyland who was responsible for running the focus group is a very experienced social researcher and was very good at ensuring that the 'quieter' participants (even if they did not put their hands up) were asked their opinion. However, there was still a group effect in that 3 or 4 participants were more dominant than most as you would expect with a group. The final two groups comprised a mixture of lay people based in Melbourne, sourced using a market research company. There were eight participants in one group and nine in the other. The selection criteria were relatively open, simply a mixed group of people over 25 years old who were mentally competent. They were paid $70 for their participation and, as the sessions were held in a private house, the host was also compensated.

All participants were given two copies of the information sheet and consent forms to read and sign, they were instructed to keep one copy as per University ethical procedure guidelines. The focus groups were recorded after the participants were made aware they were being recorded. The groups were facilitated by an experienced social scientist (i.e. not the PhD researcher) who led the discussion after a presentation of a poster (Figure 4.1) was given by me (Julie Kimber) explaining the background of the omega-3 project using similar dialogue to that used in the interviews. Technical questions were answered and the points raised by the participants were recorded onto butcher's paper (as well as the digital recorder). This aided the facilitator to delve deeper into the various points raised.

The questions asked were:

- If they currently took fish oil and why?
- Their initial thoughts about the CSIRO omega-3 project, the pros and cons of indirect and direct use of the GM oil.

- Who they thought would benefit and who may be disadvantaged?
- What could be done to address any problems or concerns to make the GM oil more acceptable?

The results from the interviews and focus groups were combined and analysed using NVivo. The coding density made it clear which views were frequently expressed. Extensive use of quotation was deliberately included to ensure that all of the main views were presented. Quotes that articulated the views of participants in the most comprehensive form, or expressed why the participant felt the way they did about that issue were selected for inclusion in the results.


Figure 4.1. Poster used to explain the CSIRO omega-3 project to focus group participants and (the pictorial only) card used for interviewees.

## Results

For the data analysis, the focus groups and interview responses were combined. The social groups that may be affected directly or indirectly by the omega-3 project have been tabulated (see Table 4.1). The views of some of the main groups are presented in the following sections, for example, the fishing, aquaculture and livestock industries, farmers, environmental groups, medical scientists and vegetarians. Not all social groups have been included in the case study, for example, the fish oil industry and indigenous groups due to logistical constraints. The potential impacts of the omega-3 project on these groups have been discussed in only a speculative form.

Table 4.1. Stakeholder analysis identifying groups that may be affected by the omega-3 project and how.

| Groups affected? | How they may be affected |
|---|---|
| Fish oil industry | May be disadvantaged if their market share is reduced by competition. |
| Fishing industry | May lose market advantage as a provider of long-chain omega-3 oils. Possible benefits from reduced pressures on fish stocks. |
| Livestock industry | Benefit from market advantages due to increased levels of long-chain omega-3 oils in meat. |
| Aquaculture industry | Cheaper source of long-chain omega-3 oil for fish feeds. |
| Oil processors and food companies | Will benefit due to a cheaper source of long-chain omega-3 oils for food processing. |
| Farmers | Broad-acre farmers may be advantaged because of the introduction of a new high value crop which fits into their current farming style.<br>Organic farmers may be disadvantaged due to co-mixing or pollen drift and subsequent legal action by biotechnology companies.<br>Either may be disadvantaged due to additional costs incurred to separate GM and non-GM produce. |
| Environmental groups | Opposed due to a range of concerns. |
| Indigenous communities and various cultures | GM technology may be in breach of cultural values surrounding their social meaning of food and relationships with food production methods. |
| Vegetarians | Benefit from land plant-based source of long-chain omega-3 oils. |
| Medical and nutrition professionals | Potential concerns regarding GM technique and inadvertent health issues, or supportive response due to associated health benefits. |
| Publics in Australia | Potential health benefit due to increased access to long-chain omega-3 oils provided it is affordable.<br>Environmental advantages – sustainability of source. |
| Biotechnology companies | Benefits from patent royalties. |
| Scientists | Career and employment benefits. |

## The fishing, fish oil, aquaculture and livestock industries

Social groups that may be directly or indirectly impacted by the omega-3 product included the fishing and aquaculture industries. Some participants thought that the fishing industry and fish oil industry may be detrimentally affected, however people may still choose to eat fish as a food and source of long-chain omega-3 oils. It is speculated that this group could suffer due to increased competition and a reduction in market share of long-chain omega-3 oils. This is dependent upon a few factors that cannot be determined at present such as future market demands, and the quantity and cost of GM long-chain omega-3 oils that may be produced if the technology was commercialised. It is also possible in hindsight for this group to use the GM land plant-based technology as an alternative or in conjunction with current fish-based sources.

The livestock industry was repeatedly cited as being a benefactor if they had access to a low cost source of long-chain omega-3 oils. Some members of the fishing industry had some reservations about the omega-3 product because it may advantage the livestock industry giving them increased competition as a source of long-chain omega-3 oils.

One commented:

> Well, from a seafood industry perspective, I'm not a great supporter of that process for the simple reason I think that it's an enormous advantage for our industry to be able to be the major supplier to the public of omega-3s. So, as soon as we make it available and already like the meat and livestock sort of ads on the television now, and they throw in omega-3s as one of their big things, and we know that they are minute compared to the smallest level of omega-3s in normal seafood. So we would be giving away an enormous advantage to them by this type of project [Melbourne, 07/07/08].

Others were not so concerned:

> Will it have an impact? I don't think so. To start off with, it might be better suited to … supplementing omega-3s in the diets of people that can't access seafood for example. Or, you know it might become a cheap way of providing those omega-3s, but then with seafood, you know, a lot of people will probably still want to eat the real product rather than something that's augmented [Hobart, 22/07/08].

The aquaculture industry is likely to benefit from the long-chain omega-3 enhanced oil if it could be produced at a cheaper cost than the present sources of fish oil. Some aquaculture representatives expressed concerns regarding consumer acceptance of commercial fish farming and the potential market impact of using a GM product.

> Well, I mean that depends on people's perception of GM foods by the time that it reaches market … At the moment, I don't think it would compete in the same area, simply because there seems to be so much public outcry in a sense against GM. But by the time this gets to market, you know, I'm guessing this is several years away, maybe things will be different [Hobart, 30/07/08].

> Yeah there'd definitely be some issues around genetic engineering. Obviously with fish farming, there's a lot of critics out there especially in the northern hemisphere. So any sort of GE or GM status tends to scare a lot of consumers, so that would be one concern I'd have if it was GE – a GE product just from that marketing point of view. Because you know we're at the very beginning really in terms of educating consumers about fish farming, so you know we want to make sure we have a positive story and not have too many skeletons, so to speak, rattling around the closets …. We want to be as transparent as possible. So we have to address those sorts of questions [that] would be asked, and we'd have to … address those either by a website or press releases and things like that. So, yeah, that information would need to be available to the public [Melbourne, 08/07/08].

Feed products may have to be labelled under the current legislation, however, this may change in the future.

> Well, I mean, the aquaculture industry has, to at present, verify that its feeds are GM free. So, I mean, again, things could change. But at the moment, they make a big deal out of that. You know, I guess it all comes back to the general public, the consumers of these products. If they don't care, the aquaculture industry won't care either. But at the moment, I think there's a significant barrier there [Hobart, 30/07/08].

## Farmers

Broad-acre farmers were one of the groups identified as being a benefactor of the omega-3 project as it would give them a potentially high value crop that could fit into their existing farming system. This was the case according to the Grain Growers Association who were supportive of the project and using the oil for the following reasons.

> It is not like a GM … round-up ready canola which only has a trait of being resistance to a chemical, this [referring to the omega-3 technology] is what we have promoted for a long time and that is to get the populace over the line, to accept that sort of technology, then it has to be a value proposition for them. And that way the proposition is that this will: a) save the oceans, b) it is good for your health, c) it can be used to renew resources, d) it is readily available and cheaper in staple foods that have been incorporated that people eat on a daily basis [Melbourne, 27/10/08].

In the focus group there were many supportive comments from the point of being able to grow the modified canola in their existing crop rotations, however, one had some reservations and suggested using olives.

> That is why I asked about the olive oil one, I try not to eat canola oil because I know what chemicals are involved in growing it. So I think olive oil would be a lot healthier [Melbourne, 27/10/08].

They would have to be satisfied that the economic returns were viable and that the crops did not have any negative attributes, for example, a reduction in yield or increased disease susceptibility. There were concerns about the potential negative impacts upon organic producers. In an interview, a farmer was asked what farmers overall may think about the project.

> Okay, so some will accept it and some will go for it and they'll think it's the bee's knees and that will be a small percentage. And then their neighbours are going to say *"well he's making a lot more profit so I'm going to do it"*. But the ones that say *"no"*, well, they're not going to have a choice 'cause their crops are just going to be spreading into their land anyway and then – as in the case in Canada where they were growing, was it corn or canola or something like that, an organic farmer, the guy with his GM crop or whatever, right next door – the roundup ready whatever goes into the organic farmer's land – the [Company X] or whoever it was go test the organic farmer's crop, find that it's now genetically modified because of the drift from the genetically modified crop and sue him for growing GM unlicensed [Hobart, 15/02/08].

## Environmental groups

It was mentioned many times that environmental groups would be opposed to GM technology. This was found to be the case for numerous reasons despite the potential environmental and health benefits. One noticeable fact was their extensive knowledge and awareness about how and where food was produced and processed nationally and globally. They were generally concerned about the industrialisation of food and subsequent impacts upon traditional forms of food production and sustainability.

> And consumers – right – citizens and yeah, people with agency who actually have the resources to make good decisions about what we're going to put on their kitchen table as well. And that we should not just be thinking about doing it for ourselves but for the world. And not be allowing the industrialisation of all of these systems because, you know, other cultures do have robust food cultures that do value whole foods and so on … our governments and these transnationals etcetera [are] all advocating to these people and pushing onto these people the products of industry and we see say, the GM soybean, I mean, it's incidental that it's GM I suppose, but in Argentina and Brazil where people have been pushed off their land into the margins of cities, huge areas that were previously so-called subsistence farms are now levelled, the villages are knocked down, the people are displaced, all to grow soybean for feeding to animals in feedlots in North America. … I mean

> industrialising agricultural systems or terrestrially productive systems like the ocean, turning them into factories, [turning] them into monocultures is not a very wise move. I mean it's not sustainable. We're asking for our life support systems to collapse and it seems to me this reductionist thinking that's associated with the idea of this – taking this gene and putting it into plants and then assuming that the plant is going to fix the problem [Melbourne, 08/07/08].

There was concern surrounding the research priorities which may be driven by industry rather than in the interests of the Australian publics and alternative sustainable options were not being considered. Other concerns about GM products were linked to potential unintended health and environmental impacts. Overall, most had a high level of regard and trust in the CSIRO, but expressed concerns that this may change in the future if more industry funding is sought.

> I generally don't like genetic engineering in food and agriculture, but it's for quite a few reasons, I mean, I am concerned about the environmental implications, because I don't think that we understand them very well. I'm also concerned about just the cost benefit, 'cause I think that a lot of money is directed to genetic engineering research in agriculture and, for example, in CSIRO there's no funding now for organic research, and I think, you know, in terms of looking at agro-ecological options and that kind of thing, they very much lose out in the face of this … quite consistent interest in GM. And then at a health level, I also have concerns about GM. I don't think we understand very well the sort of potential dynasty and that kind of thing, and it's not so much the concern that something really dramatic is going to go wrong, but just that – the potential for all sorts of things that we don't predict. … I think CSIRO just holds such a dear place in the heart of Australians, and that having an institution like this is so valuable. It has such a strong record of achievement in the past. And I am just quite concerned that a lot of the recent research that CSIRO does, I think, is driven by a desire to deliver commercial – seeing marketable outcomes, whereas I would like to see, for example, a stronger investment in what I would consider to be public interest science and things that might not actually deliver a good financial return in the short term, but perhaps things like, you know, invest in sustainable agricultural research and things that have a demonstrable value in the longer term [Hobart, 29/08/08].

> There was more concern about multinational corporations and concerns that GM technology is perpetuating the problems associated with current farming practices and may also introduce new environmental risks. … I'll be honest with you. I have a huge respect for the CSIRO. … I am always worried about genetic engineering and it's probably because of the companies like [Company X]. I think that if there is anyone who has credibility that I would listen to, it would be the CSIRO [Hobart, 12/11/07].

> At the top of the list for me in fact are concerns about control of food supplies, and increasing corporate control which I see GM being inextricably linked up with. There's broad environmental concerns, both in terms of the continuation/ perpetuation of existing problems in agricultural production, and environmental problems such as the problems of soil erosion, water use, chemical use and loss of diversity. I see this technology as simply expanding and perpetuating some of those problems and in some ways further entrenching them even while offering supposedly … mediation [to] some of those problems like the lessening of chemical use. I see it … also introducing the whole range of possible new ecological hazards and risks [Melbourne, 24/09/08].

One participant was concerned about the consequences of reductionist science in the food industry to create products such as functional foods instead of encouraging a balanced diet based on whole foods.

> I can see a whole lot of problems there and then there's a further translation of that nutritionally reductive knowledge and science into what I call nutritionally reductive practices and more specifically nutritionally reductive technological practices and that's when we actually start taking fairly reductive and I think fairly simplistic view of food, particularly the focus, the even more reductive focus, on single nutrients such as omega-3s. … The functional foods which, you know they're heavily processed, not particularly healthy foods, you know, white breads, all very processed foods, so you know there can be benefits potentially by going down this line of enhancing the long-term omega-3s in this product by this technique. But I'd like to see the equivalent research going into you know education and a healthy balanced diet [Melbourne, 24/09/08].

There was particular concern about using highly processed foods as a functional food instead of healthier options.

> So, for example, the stuff here that's being fortified, this Tip Top UP stuff, I mean, it's such highly processed bread, I really seriously question the health value of that bread, even not being fortified with the omega-3. So I'm concerned that, like if this … bread is fortified with omega-3 and then marketed supposedly for its health promoting qualities, what happens if people eat this highly-processed bread and they don't go and eat perhaps a better quality, less-processed bread, a wholemeal bread, or something which perhaps has a greater nutrient value [Hobart, 29/08/08].

This group also advocated a review of current food production practices:

> So, we need a whole realignment of values and perspectives. And so, things like the Farmer's Market Movement and City Farms and growing your own and the organics movement and now industry, the values that underpin those things are the kinds of things that I think need to come to the fore and that we need to stop calling food commodities and start thinking about it as food again [Melbourne, 08/07/08].

### Medical scientists and nutritionists

The initial interviews with these groups indicated that they were generally sceptical about GM technology in general. A focus group was held to investigate the views of other members of this group. Their concerns revolved around the potential for undesirable long-term side effects on human health. Like other groups, they expressed concerns about the legal and socio-economic power of the biotechnology corporations and the potential negative impacts on non-GM farmers.

Julie: Alright. Can you think of any … social groups that might oppose the technology?

Interviewee: Any social groups? Well – I'm not sure what social groups. I don't know the names of any groups, but I know there is widespread opposition to GM in Australia. I know individuals more so, well I know the dieticians generally. The Dieticians Association of Australia may not have an official position against GM food, but every dietician I know is vehemently opposed to GM food, or the vast majority for some reason.

Julie: And do you know what those reasons are?

Interviewee: The reasons they give include things like potential unexpected side effects. The reasons individuals quite often give are, well, you're interfering with nature, it's unnatural. It doesn't matter that nearly everything we do is unnatural anyway. Wearing clothes is unnatural, driving cars is unnatural. They do all these things (chuckle). We don't eat a natural diet anyway because the palaeolithic diet is quite different to the diet we eat now. Wheat and dairy weren't eaten until about 10,000 or 15,000 years ago and yet they're two of the four food groups that we – well grains and dairy that we live on now. So that the natural diet argument, I think, is fatuous. The potential for unwanted side effects is possible [Hobart, 17/09/07].

Another medical professional stated:

> The difficulty is that people who work in those areas (referring to medicine) … tend, I think, … to be a bit sceptical about the molecular biology technology. They still think [that it] seems to be a little bit hit or miss, that you act, if you know, muck around all sorts of mutants in the hope that one of them actually takes. … So [there seems to] be a little bit of a scepticism about how well it's going to work and more particularly are we going to drag other things along with it? … Are we going to also put across something else we weren't expecting and end up making … and bringing in things which makes perhaps a less desirable [Hobart, 29/09/07].

Some of the reasons underpinning their scepticism were related to unpredictable genetic consequences that may occur as a result of the GM process which involves multiple genes and the creation of unintended toxins. There were some suggestions made in the focus group that might alleviate some of the concerns. One person mentioned that canola may out-cross with other plant species therefore other crops like cotton may be more suitable. Others advocated the desire for long-term human health testing.

Focus group participant 3: I suppose I see that, particularly if you moved a large number of genes just to whatever, what is going to happen to the metabolism of the plant overall? And you know, may be these long-chain omega-3s, but what else is produced as a by-product, so I always wonder about the safety aspects of it, and you know, will it be tested thoroughly or not? How can we know how those genes, or the products of those genes, might interact with other things in the plant … Let's say that there is some toxic metabolite that happens to be produced by the plant – if you put that through a cow or a chicken first, it really depends on how that animal deals with it, does it accumulate it in its muscle, in which case it is going to be a problem if we eat the animal, or if it is accumulated in its milk or its eggs. Or it may not. Maybe it just, you know, runs through the animal's body, causes a little bit of a problem, but not too much, you know, it does not actually accumulate, in which case the indirect use may be potentially safer. But I think we don't know until – we'll have to see what happens, won't we?

Focus group participant 4: I mean the whole concept about it, I have thought of another positive is that we are all aware of the potential issues of feeding animal protein to farm animals it is just that we have already had a global disaster about this [referring to mad cow disease] so this is good, getting a good animal feed [derived from plants]

Focus participant 1: Well yes except if it accumulates the same toxin.

Focus group participant 4: Well obviously that would not be good.

Focus group participant 1: No well a toxin is fine because you will recognise that but it is something that is slowly accumulating and has a long-term carcinogenic or genomic effect then so we might actually.

Focus groups participant 4: It is not likely to be licensed is it?

Focus group participant 1: How would you find out? That's the problem you can't ever prove that you don't have any negative consequences in the end if it is something influencing our genetic makeup it might take generations to start getting into future children but it could happen.

Julie: So do you think there should be some epidemiological testing?

Focus group participant 1: Very much so, yes but again it would have to run over generations in humans, not just mice or monkeys so it is impossible. [Hobart, 20/10/08].

Some participants were less concerned about the omega-3 project itself and were optimistic about its potential to reduce the pressure on fish stocks.

> I think, like when someone looks at this and its environmental role, and fish stocks are heading down while people stocks are heading up, so I think at some point there, we will be running out of fish. So people will have to eat more plants, and you know if there is a lot of science – I am not terribly familiar with the omega-3 literature, but generally it does look like there are clear health benefits – so you want to try and get it into plants because eventually people are going to have to face the fact that they are going to be eating lots of meat plus fish and more vegetable matter. I am talking very long term now, in probably the next few decades. So I think ultimately this should benefit. It is hard to know for sure [Hobart, 20/10/08].

Despite being concerned about GM, some were supportive of this particular project because of the health benefits:

> On the weekend I was speaking to a Tasmanian farmer who grows canola for the Japanese market who told me that they were secure suppliers only because we are GMO-free in Tasmania. Since Canada introduced GMO canola recently, they have been cut out of that market. These are obviously very real problems for genetic modification, and strong evidence of benefits far outweighing risk is going to be needed to change attitudes [Hobart, 20/10/08].

Another interviewee commented:

> Terrific! If it succeeds [the omega-3 project], terrific for human health, yeah [Hobart, 17/09/07].

One nutritionist was not against GM technology but reiterated the need for labelling to enable people to make an informed choice, which they thought would be opposed by commercial companies.

> Well, I mean, I think it holds quite some promise, and as you're probably aware, I have been casting doubts on genetically modified foods, on the ones that we have at present. I have made sure that I have said on all cases that I actually am not against genetic modification as a technology; I just have a problem with the degree of testing and lack of labelling on the current genetically modified crops. I personally don't have a problem with genetic technology that gives it a use. And, in fact, one of the examples that I have been quoting is that we could use genetic modification to get a wheat that is not a problem for people with gluten intolerance, and we could also get some omega-3s. I mean, I'm aware that this project is happening, [putting] some long-chain omega-3s into plants. But I thought that would be a useful approach to take for genetic modification. … And because there is kind of an issue, well should we be labelling GMO foods, and I say, I have to answer 'yes', but whether or not it is going to happen, because there would be affirmative opposition from the big end of town for that – I just think people have the right to know what they are eating, and I think if it were labelled, then people can make that decision. I mean, some people may be perfectly comfortable eating genetically modified food, and if so, you know, what's important is if you are not comfortable with this, then, you know, read the label [Sydney, 29/08/09].

Another barrier pointed out was the lack of knowledge about different sources of omega-3 in the general public.

> Julie: What do you think the public know about these nutrients? You know, do you think they know the difference between omega-3 and the difference between long and short-chain?
>
> Interviewee: They definitely know omega-3 is good and that's about the end of their knowledge. I think there's very little understanding of the differences between long and short-chain. They don't know what long and short-chain means just on its own, and I don't think they have any idea about the different sources. So if they see omega-3 on a margarine and an omega-3 on a fish, but they don't really know if it is any different [Sydney, 29/08/09].

## Vegetarians

It appears as though vegetarians may think that canola oil already comes from GM canola, this was also the view of a nutritionist. There were mixed responses about how vegetarians would take to the product, one stated a preference for an algal source as she did not use supplements or consume processed foods.

[Interviewee: A vegetarian that eats a bit of fish but not meat]

My first reaction to it is that I would rather eat the algae if that's what produces it. I would rather not inflict any unintended consequences on anything else before it gets to me, let me make the decision whether I want to take that risk, so if I don't want to take that risk, and [I would rather] go down to the source to get as close to the source as possible. So, is there some way of actually having it direct from the algae that you buy that you can eat, 'cause I don't take supplements? … Putting it into canola would not be any use for me whatsoever, because I don't eat canola oil because it is generally GM. You cannot guarantee at all now that it isn't GM, genetically modified, so I don't buy it. The difficulty is, I do go to the fish shop generally once a week with my little booklet telling me about all the endangered species, and I find it increasingly hard to buy fish, so I usually end up eating my weekly tin of sardines because I am aware that they are depleting the sea and if I could avoid the fish and just go to the algae, that would make me more comfortable. And because I don't eat processed food, anything that is processed is not going to get to me. I would rather farm it, have my own little yoghurt maker, or algae going and feed from the algae directly because I don't eat meat [Hobart, 2/10/08].

A nutritionist also commented that some thought that canola was already GM.

Interviewee: They're very interested in where can I get it if I don't eat fish? So I get a lot of interest from that. I get a lot of questions about that, "*I'm vegetarian and don't eat fish*". Obviously vegetarians are quite healthy. "*How come? Where do we get it?*" A lot of them are aware of flaxseeds. Vegetarians are aware of flaxseeds, but they don't understand that flaxseeds and linseeds are the same thing. They think flaxseeds are something different, but they've read stuff, you know, they've read stuff from North America which refers to flaxseeds so that vegetarian – I'm talking here just about the vegetarians who are interested so they are aware that flaxseeds are a source – they're often aware canola is a source and there's quite a few of them that have bad feelings about canola. These are vegetarians I'm talking about

Julie: From what point of view?

Interviewee: Well, they think it's genetically modified already. They read this stuff that it contains … that it's a rapeseed oil and that it's got nasty things in it. These are the ones who are interested enough to bother asking and they often have a lot of misconceptions [Sydney, 29/08/09].

Another person commented that vegetarians would benefit.

Right, well given that, then, I think it's fair enough, having a daughter who's a vegetarian, I would see this as being particularly pertinent ... because she would be able to consume this either in the form of a finished product that's been fortified or directly as you said in capsules, so yeah and there are a lot of vegetarians and people like that out there. So I think that's pretty good [Melbourne, 25/09/08].

## Indigenous populations and specific cultural groups

Participants anticipated that a range of particular groups would be opposed due to their specific cultural norms and values. These may reflect values and beliefs about the social meanings of the way in which food is produced, processed and consumed and the relationship they have with the world. Their conceptualisation of risk is different to those who decide the criteria making scientifically-based risk assessment invalid for these groups, and some environmental groups.

> Well, if you look at a few years ago, there was a Royal Commission of GMOs in New Zealand, and the groups that were most antagonistic towards GMO technologies were probably two. Firstly, church and religious groups, and secondly, traditional communities, New Zealand Maori communities who really found the GMO technology represented an assault on the relationship between human beings and the land … There are also many groups, some of which include scientists, who simply oppose GMOs notwithstanding on really just ethical grounds, although sometimes there's that concern … many environmental groups would be antagonistic, but [it is based] simply on the grounds that they don't accept the assessments of risk, they do indeed think the technology is fundamental and it changes the context of risk assessment and so on and so forth. And the way to deal with that, it seems to me, is to have a proper discussion that doesn't automatically privilege fundamental scientific [views]. … Yeah, or a particular scientific assessment and I mean part of what I'm saying, too, is that the scientific assessment, strictly speaking, is not univocal on this in the sense that … if you accept the point that risk assessment is no longer reliable in this context, then a lot of the scientific discussion is no longer well-grounded, right. So a lot depends on whether or not you think the risk assessment is well-grounded in the first place, alright. I really don't see how we can claim it is, and I think the sorts of decisions we make about GMOs are actually based much more on a set of broad brush generalisations that aren't [about] sound scientific assessment [Hobart, 19/12/07].

A comment was raised about the sensitivity of different cultures to new food technologies.

> If we take away the environmental movement, which by and large is opposed to genetic modification, and I know that is generalising, you've also got cultural groups which eat according to their culture and have to face every new food with some suspicion … until it can be demonstrated that it's appropriate [Hobart, 18/07/08].

## Specific issues that arose from the research

Chapter 2 (The potential issues pertaining to the use of GMOs in Australia) was a review of the literature and it highlighted a range of potential issues. The questions posed to case study participants were aimed to flesh out concerns and seek solutions to increase acceptance of the omega-3 technology, others were of particular interest to CSIRO, for example, people's thoughts about the pros and cons of using the oil directly or indirectly. The importance of some issues that were frequently raised throughout the case study are discussed below in more detail even though many issues in the results have already been mentioned and often overlap. This is to be expected as people belong to or identify themselves in a range of social groups. These issues include the levels of trust in various agencies and thoughts about labelling. There were also comments about potential non-GM sources of long-chain omega-3 oils.

## Direct versus indirect use of the product

There were many different issues associated with the oil being used directly and indirectly according to the product that it was intended to be incorporated into. These primarily reflected ethical (rather than risk related) issues to do with choice and the need to have labelling to enable the customer to be able to make an informed decision about whether to purchase a particular product or not. Overall people were unaware that cotton seed oil was predominantly produced by a GM process and this evoked a negative reaction when it was discussed.

The presence or absence of genetic material in the product and the potential health impacts was not the primary issue, but the construction of a ‘synthetic’ as opposed to a more ‘natural’ source of long-chain omega-3 oils caused concern.

> I’m still going back to this thing, if we have a tablet of the canola oil or a capsule of the canola oil and a capsule of algae-genetic canola oil, there has to be a difference, and when there’s a difference, there is going to be a different effect. Now whether that effect risks your lives, we don’t know, but going back, if there is an effect whether or not the DNA, the material, is there or not, we do not know what that effect being something which naturally does not have that structure is going to be, so it needs to be labelled, definitely, and we need to have the choice [Hobart, 2/10/08].

Generally people were accepting of the omega-3 projects oil as long as it was labelled to allow people to choose if they wanted to purchase or avoid products.

> I would definitely say for myself, the direct use because there is always going to be more choice on the marketplace to opt out, and I don’t think you should inflict uncertainty on other creatures just for our own benefit apart from the fact of not knowing what the effects are going to be doing that [Melbourne, 24/10/07].

This was reiterated by other participants.

> Well, I’d say the direct use, you’re actually far more aware that you’re using it. You’ve made a choice to take a capsule. So you know, from an ethics point of view, you’ve made a conscious choice that’s what you want in your life, that’s what you’re doing, it’s only affecting you. Again, margarine etcetera, you’ve made a conscious choice to purchase that. Whether or not you get that same upfront approach with the

> functional foods, again that's a labelling issue, isn't it, that's saying, "I've … had canola used in me to boost my level of omega-3" [Melbourne, 24/10/07].

Some focus group participants were unaware of the labelling laws surrounding GM foods but were happy to use the GM oil if the price was good.

> Julie: I am just interested to see what you think - should it be labelled specifically as a process of GM or a product of GM or whether you are quite happy with your cotton seed oil (most did not know it was produced by a GM process) at the moment as there is no DNA in that actual oil because it is so refined that the DNA is removed anyway, but do you think from an ethical point of view that some people would like to see it labelled as a process of GM?
>
> Jeanette: For the benefit of the tape people are nodding yes!
>
> Focus group participant 3: As a selling point with omega-3 to say that it is GM. I thought they already had that - that they had to state that things were GM.
>
> Julie. Only if it is above 1% in the product.
>
> Gasps, Wow! (People were surprised).
>
> Julie: I am just interested to see what you think, if you were in a supermarket and you have got one that says - this canola oil is made from a GM process but it contains long-chain omega 3s which are really good for you or something, and the other one says GM free you know would some people go for one or the other?
>
> Focus group participant 1: If this becomes more expensive and you know this one is \$3.50 and other one is \$2.00 and for ever reasons say the credit crisis continues then people may go for the \$2 one, but if there is only 10cents in it or whatever then you say whatever, you know it has got a little bit there for the kids or for aunty whatever.
>
> Julie. So you think price is going to be a big thing?
>
> Focus group participant 1: Yeh I do, I get the best product for the best price but don't necessarily buy the cheapest.

Other issues related to the cost and taste of the various products, and confusion as how to achieve the recommended daily intake of long-chain omega-3 oils and whether it was possible to overdose. There was also confusion and issues related to current labels on packaged goods, and total confusion about the difference between long and short-chain omega-3.

> I think it is going to be the way you sell it really. If you put it into bread and you put it on the front of its packaging, then people go "Ahhh, omega-3s, I can eat it directly". It sits more comfortably with me if it is in a bread or a fish oil capsule just so that I know it has been genetically modified previously [Melbourne, 28/10/08].

A food industry representative thought that only a small sector of the community would consume functional foods.

Julie: So what about functional foods then? Where does that come into that … marketing thing? I mean, is it the consumers that are asking for those or is it more industry driven?

Interviewee: There is a small sector of consumers that are interested in their health and the health benefits and that don't want to be taking vitamin tablets and vitamin pills, that they do want a healthy diet and a long ... active healthy lifestyle. But it's not the vast majority of consumers, it's a small sector, so you know they're the ones … [who] buy and consume for themselves and they tend to be the baby boomers and that group. There is a small sector that is focused on the health and well-being of their children [Canberra, 17/12/08].

Some expressed concerns about the sensory factors related to smell and taste of fish oil in functional foods.

> I think there's a definite need to get it other than just being able to take capsules as a supplement. I think we need to be able to get it because the people like me, you know, you're not going to be that keen to take capsules, or you may forget to take them. I have bought bread. Terrible fishy taste, kids wouldn't eat it unless you were having grilled cheese or something. I mean the smell that came out of the bag so that stopped me buying the bread [Hobart, 27/08/08].

Other issues related to how expensive the end products may be.

> I think the direct uses generally, with the exception of breads and cereals, won't do much for them (referring to lower socio-economic groups) because they don't have the spare cash to spend on capsules, and yeah maybe they eat sardines if they like them. Again, they're not going to go out and buy an Atlantic salmon because it's expensive [Hobart, 18/07/08].

Some participants realised that olive oil may be more expensive than canola which was viewed as belonging to the lower end of the market.

> The other issue which I suspect will come up, which is a barrier, is that if all these things are duly covered by patents or the other legal apparatus, they will become more expensive. And I suspect canola is not one of those things which people are used or willing to pay large amounts of money for. Probably now with the olive you'd probably get away with olives to some extent because olives has got a more upmarket image, but canola is seen more as a workday cooking oil [Hobart, 24/09/07].

Other issues related to achieving the optimum 'dose' of long-chain omega-3 oils.

> You know, you're so unsure of the dosage in these products. I mean you can make good guestimates and everything, you know, the size of the cow, how much the cow eats, what other food it eats. Direct, you're far more conscious of what your dosage is, yeah, it's a bit of a scatter gun approach I think, doing indirect. But there you go [Melbourne, 24/10/07].

For some participants, the balance between cost and dose would be a factor that would influence their decision which direct application they would prefer.

> It is a case of getting the daily amount, you would have to eat three loaves of bread to get it and it may cost $5 for a loaf of bread, so I would much rather take the tablet [Hobart, 28/10/08].

The indirect use has the potential to incorporate long-chain omega-3 oils without creating opposition from anti-GM publics.

> The advantage of the indirect use is that people will then not be eating genetically modified organisms. They'll only be eating the product because if these cattle are eating the canola then the canola itself won't come into the people, into the consumer. So I can see a benefit to the people who are concerned about GM food and who are maybe anti-GM, but this is a way of getting the GM product without taking the GM. Direct use: I would imagine concentration is going to be much greater if you are eating canola directly rather than diluting it through cattle or sheep or chickens or whatever. So I can see a benefit of greater concentration, getting more of the product through direct consumption. They're the main differences I can see between those two [Hobart, 17/09/07].

It was seen as being a less efficient way of using the oil by some other participants.

> Well, fitting it in to the animal products, indirectly via pellets and so on, the technology wasn't ideal when it went through its popular phase in the '80s and early '90s and it's a bit expensive thing to do. Try to stop the gut bacteria from breaking down the omega-3s before they get absorbed [Hobart, 24/09/07].

One perceived problem a major food industry representative mentioned was how to market products. Some thought that a sudden increase in concentration of long-chain omega-3 oils in meats may create suspicion.

> The indirect one, okay it's still the same thing, the question is how you get the message across. Okay. Grain fed poultry with added omega-3, I don't know. How did you get the omega-3 in there? Did you use a syringe and inject it in or, you know, all sorts of stuff. Some of the conceptions that consumers may have about it, it's much easier to say, you know the bread has got added omega-3 oil than it is to say the meat is from cows that were fed on grain that was derived from [GM long-chain omega-3 oils] [Canberra, 17/12/08].

As the margarine industry has been marketing the presence of omega-3, it may be easy to use this as a medium.

> In Australia, and I mean other parts of the world, now getting it into functional foods, margarine capsules, people who are taking capsules, I think will probably be … will accept it. I don't think it's going to be too much problem there. Putting into margarines and so on, margarine and oil people have been pretty sophisticated in trying to push the omega-3 message up 'til now. And then I talked to some people in the margarine industry, and I think if something like this became available, they could think of something omega-3s without otherwise causing problems. They would be willing to try. And I think there could be a technology issue with the margarines and that fishy taste [Hobart, 24/09/07].

An oil processing representative commented that shelf life may be problematic if the products could not be stabilised.

> Besides the GM, ... the taste and stability. Particularly depending [on] what product you were putting it into. If it's a shelf stable product, we would have some shelf life concerns. So we'd have to have a look at that. Again, I'm not sure if we can manipulate fatty acids on the triglyceride ... there's talk that if it's, you know, the most reactive is in the second position, it may be protected somehow. … So stability would be a major issue and then you know, taste obviously. So that would be I think the biggest barriers that you probably face in terms of the oil side. … If it's used in frozen products it's probably less of an issue, you know, freezer products or frozen products, but if it's in biscuits or baking products, or even snack foods where you have a shelf life of 12 weeks, six months, [that's] probably going to be a bit of a concern [Melbourne, 28/10/08].

Milk and milk products were also cited as being good ways to reach a wide population.

> I am thinking what if this project instead of looking at micro-algae and putting that into fish. What if the modified canola was actually instead fed to cows and pigs for instance, and that gets transported to milk. You know, milk is a beverage that most people would take, and that [omega-3] comes in through [in] milk. You know, would that make it more acceptable? Or then processing this into cheese with much of the advantages of the omega-3s still being retained in the cheese? And I mean most people would naturally just go for it in cheese. Are those options worth pursuing instead of incorporating it into fish? [Hobart, 12/08/08].

## Trust

There were various comments related to the level of trust in various actors and agencies that influenced the acceptance of the GM omega-3 product. There was generally a high level of trust in CSIRO, even amongst most of the anti-GM environmental groups, despite concerns about the influence of industry funding for commercially orientated research rather than research in the interest of the public.

Another negative influence on the acceptance of GM was the level of scepticism about the power of biotechnology multi-nationals, and concerns about the power of food multi-nationals. Agencies responsible for GM technology and food regulation evoked a mixed range of responses: some considered it over-regulated, others thought that more needed to be done to ensure that human and environmental assessments of GM products were undertaken by an independent agency.

> I have trust in FSANZ, but I think all government departments should be working a lot closer with the industry to try and resolve these issues, and it's still that issue of tending [to be] a bit of one-upmanship all the time, and not really telling each other true. And I think we've still got a long way to go in that area. I think also the industry, the seafood industry, is starting to realise that its getting involved in the world scene is actually important from a perspective if you take things like CODEX and other issues. We need to be involved at the decision-making at the top of the

pyramid and not we normally get involved when the decision has already been made and we're half way down that pyramid [Melbourne, 07/07/08].

Some thought that some industries were over-regulated.

Interviewee: The regulation, in my view, and I'm familiar with it from a fish farming point of view, in Australia we have extremely high level of regulation which does give us what I consider a very high degree of food safety which is necessary, but I can't help feeling that in some areas, it goes overboard. Actually, I must say in my view, it goes overboard – not in the context of human safety, but in the context of impact on the environment. We seem to cheerfully take an extremely low risk approach to what might be environmental harm, although there seems to me, a lack of risk based assessment on the sort of decisions taken.

Julie: Are you thinking specifically about genetically modified plants?

Interviewee: Yes, I mean clearly the concept that we cannot have genetically modified crops in Tasmania seems to me to be a bit of a blanket statement. Obviously we hear on the other hand the concept of genetically modified crops escaping and the big bad [Company X] of the world suing people. All those things notwithstanding, in my view we've got an extremely tight and high level regulation on food safety. But … I think it's more to do with environmental impacts than human food safety [Hobart, 15/07/08].

Others expressed the difficulty in balancing the amount of regulation and the associated costs against risk especially as science advances rapidly, sometimes ahead of regulators.

This is a really hard one because I'm not a great believer in over-regulation, because I think the more regulation you impose on the food industries, the more expensive food becomes and therefore the less available it becomes to certain parts of the population. Having said that, you've got to have some regulation. You've then got the cost of administering the legislation and regulation. But in general I have faith in what's done because, yes, you get salmonella outbreaks and you get this and that, but regulation can't stop that, all it can do is minimise it. In terms of the actual nutritional value of the food, there's a lot we don't know yet, and so I guess we're always lagging behind the science, and so what regulation says today about what you can have and what you can't have will change later on. Not regular guidelines, science is always ahead but … five years before it can be demonstrated [Hobart, 18/07/08].

One food industry representative was satisfied with the current food regulators.

I think FSANZ has got a bit of a chequered history, but here specifically we're probably more talking about the Office of the Gene Technology Regulator, and I've got a lot of confidence in that office, and they do a lot of polling and surveying and talking to people and informing both consumers and industry, so you know I'm comfortable with what comes out of there. I think it's a fair and balanced assessment of the state of play [Meltone, 25/09/08].

A representative of an environmental group was not at all happy with the food regulators.

Julie: So, what do you think about the regulation of genetically modified crops in Australia? Like, do you have trust in the regulators like FSANZ?

Interviewee: No, not at all. We don’t trust them and the reason that we don’t trust them is that they don’t use a scientific paradigm to do their work. In a nutshell, our argument about the current system is betrayed by their own use of language. They say we run a science-based system. But their ad-hoc, so-called case-by-case system is actually a way of accepting from the proponents a suite of quite unsatisfactory evidence about the safety, efficacy and environmental impacts of their organisms. Our argument to the government and to the regulators constantly has been for a long, long time that we want a scientific system, which actually applies the rigour of science to assessment.

Julie: So, that’s peer reviews, you mean?

Interviewee: Well, it would involve peer review but most especially, I think that by regulation, the regulator should mandate the evidence that will be required in advance so that everybody knows where they are. So that, if an applicant is going to develop something from scratch, then they know during the course of the development of this organism and this product, we have to do certain experiments. They have to be of a certain size, a certain duration. They have to be designed in a certain way that’s robust, follows genuinely scientific principles, and will produce data which is reproducible, which is robust and reliable. … Well, even if it doesn’t come from the multinationals directly, it’ll be something that a multinational has commissioned. And we know perfectly well that the person who pays the piper you know calls the tune, and that it's very easy to get the results that you want out of such experiments. So, that’s unsatisfactory [Melbourne, 08/07/08].

A nutritionist was concerned that FSANZ had a limited portfolio, which should perhaps be expanded.

Interviewee: I’m not meaning to blame FSANZ. They just don’t have enough resources and also the fact that FSANZ doesn’t have to consider environment – in fact ... they don’t even have the brief. They’re not even permitted to consider environmental impacts of any of these statements. I spoke to them just two weeks ago actually, asked you know “when do you consider it?” [the environment]. And they said, “look, we don't at all because it’s not in our brief and that’s somebody else’s job, not ours”. But, in fact, it turns out that it’s nobody’s job half the time. So I think FSANZ would be fine as long as it’s backed by proper tests done by people that are seen as independent and CSIRO have probably fulfilled that role.

Julie: So they’ve got to have more resources to be able to conduct the tests? And what do you think about Judy Carmen’s work with further testing on epidemiological studies?

Interviewee: Oh well, I mean I think that’s quite important. I think, you know, Judy’s a reasonable person [Sydney, 28/08/08].

## Labelling

There was wide spread consensus about the need to label GM products, not just from the environmental and anti-GM lobbyists. The current lack of awareness about the presence of GM products in the community due to lack of labelling was stated by a number of participants. For example, a representative of a major food company commented:

Julie: Do you think they're aware that they're already consuming GE products, like cottonseed oil, seeds and that?

Interviewee: Well, many of them probably wouldn't be, yeah they wouldn't ... they would believe that, you know, something as simple as – well if there is GM there, you're required to label it – not realising that there are some you know aspects of the legislation or regulation that may be of such highly refined things like oils not to have to be labelled. And so personally, I don't agree with that, … again I think we should probably have taken [an] ... earlier stance in saying well this doesn't have any genetically modified material in it, however, it was derived from an organism that was transformed.

Julie: You think it should be labelled as a product or a process?

Interviewee: I think we should have started that way because I think if you don't then you open yourself up to this whole, you know, what are they hiding … to all of these activist groups. And although obviously ... there's going to be an issue there, and there's going to be some misunderstanding and fear, at least [if] you're going to address it, address it with good solid science by respected people that consumers will listen to. But at the moment, it's almost like we've buried our head a little bit in the sand, and we don't want to tell consumers or, you know, they don't need to know – I think is the way I would sum it up and I just don't think that's right [Mentone, 29/09/08].

Focus group discussions also brought up clear labelling and what the origin was of omega-3 being used in food products.

Jeanette: So would you like the lady was saying that she would, like to be able to read the label?

Focus group participant 3: I am getting too old I can't read half the labels (chuckles) no its like I buy something and how it is preserved and things that are dangerous on one side you can hardly see them, you know I take my glasses along I have got long-sight not short-sight and I almost have to take a magnifying glass as well as my reading glasses to read them because it is in very small print that they don't really want you to know. I'm very suspicious and am getting more suspicious as I get older. (Chuckles)

Jeanette: You are talking about labelling and that would be the issue for you too but it would need to be labelling in order for you to have a choice.

Focus group participant 6: It has to be totally optional wouldn't it I mean you could not just make it standard across the board like fluoride is in our water.

Jeanette: So you would want to be able to see which product had it in and which didn't so you could make a choice.

Focus group participant 6: Absolutely.

Focus group participant 2: But most new products now are coming out with it and you just don't even know. You know like the 7 up bread that is full of all that omega-3 in it.

Jeanette: But where does that omega-3 come from?

Focus groups participant 2: Oh well it has been enhanced so I don't know where the omega-3s come from but most of your ordinary breads now that are all coming out with omega-3 all through them.

Julie: The omega-3 is the long-chain type that comes from fish oil.

Focus groups participant 2: So it is not genetically modified, so in that case they have just poured it into the process. I suppose one thing I would have about genetic modification is just the preservation of the original seeds so we don't actually lose those original, do you know what I mean.

Focus group participant 7: If it oxidises does that mean they will be putting more preservatives in it?

Julie: Some of the anti-oxidising agents that they use are like vitamin E, that's a commonly used one that is often in fish oil capsules as well because vitamin E is a strong anti-oxidant.

Focus group participant 7: Anti-oxidants are supposed to be good for you. [Melbourne 28/10/08].

One question that arose about food regulation was whether the GM canola oil has to be labelled by law. Labelling was an important issue with the participants. One participant made the astute comment that the oil was 'changed' from the original oil, which made it significantly different from GM cotton seed oil.

> from what I understand about cotton seed oil, it's the gene – I'm trying to get this right here because I have read about it – is the gene technology, well the genes that are inserted in it in order to produce the chemical resistance. But the oil itself wasn't supposed to be changed at all anyway and [when] they had finished the processing, the oil is just … pretty pure and that is why it does not have anything in there. Whereas this, because of what you are wanting in it, is <u>changed</u> from what it was, there must be some change to me, there must be some change in the final product, in the final oil product [Hobart, 02/10/08].

A representative from the oil processing industry also thought that it would have to be labelled as a GM product according to FSANZ standard 1.5.2. GM – 'Food produced using gene technology' as it has altered characteristics.

Interviewee: This would be the case from my interpretation for food products consumed directly, and on animal feed packaging, not the animal products that are consumed by humans. … If you read the labelling guidelines, if you change the characteristics of the oil through a genetic engineering thing, you have to label it as GM. So perhaps, for example, like a long-chain you know fatty acid that's not normally in the canola oil, but now there is, then my understanding of the labelling guidelines is that you have to label it GM. That's how I've understood the labelling requirements. If you don't change the characteristics, like you know GM canola or GM cottonseed, then, you know, it's a highly refined product, then you don't need to label.

Julie: So even if the long-chain fatty acid appeared in your oil, you'd have to label it GM even though it doesn't contain any protein.

Interviewee: Correct, that's how I understood the labelling regulations, actually I can email them through, the relevant section.

Julie: So the supermarkets would also have to label it like that?

Interviewee: It would be on the pack. Yeah well, on, you know, the nutritional label [Melbourne, 28/10/ 08].

## Genetic modification and non-GM alternatives of long-chain omega-3 oils

Some participants asked whether alternative non-GM sources of long-chain omega-3 oils were an option. There were questions posed as to whether the algae themselves could be used instead of using a GM process.

One food industry representative summed up the following concerns after being asked about their initial reactions about the omega-3 project:

Interviewee: They're putting it into canola oil, obviously it has the advantage of being able to [be] easily propagated [into] … crop production as opposed to trying to grow and maintain a micro algae. The disadvantage as I see it is that it is presumably genetically modified canola, there are some barriers for consumer acceptance. ... So there are some consumer acceptability barriers with GM crops as you're aware because it's an oil that is coming out of the GM crop. As a highly refined oil, it's possible that you might be able to overcome some of that resistance with consumers because it doesn't contain any novel DNA, and it does not contain any novel protein and therefore the Australian labelling requirements may not require a GM label. But there is a counter argument that you have genetically modified the crop to specifically produce a characteristic and the characteristic is a novel characteristic and therefore would require a declaration. So I think that's going to require some careful thought about how you go with that.

Julie: Any idea what consumers want with regard to labelling like that, have you heard anything?

Interviewee: The consumers are … a diverse group and you could probably divide them into four or five different sectors, into groups. At the most extreme end, you have the consumer advocacy groups that are strongly opposed to GM technology and want full declarations for everything and you know all the rest of it; and they will take ... a very strong position to say that it's omega-3 from GM canola. Then on the other hand, you'll have consumer groups – consumers that are in the middle – you know, [it] doesn't contain GM stuff in it and it's just refined purified omega-3, we don't care. And then you've probably got, you know, the brickies labourers down the far end. Sorry to stereotype, but you know those that don't even read the label, don't give a damn, just want something to eat, thanks very much. It's terrible stereotyping, but there you go. … But it is one of those areas where the consumers that are most vocal and most resistant and most active and campaign most strongly against GM are going to be the groups that fall into the Greenpeace bandwagon, and that with Greenpeace promoting their latest publication on 'Don't Buy GM', whatever it's called, off the top of my head I can't remember ... Greenpeace was in that promotion going to companies and saying: "*We want your company policy and your company statement that you will not use GM ingredients. And if you don't say that, then we're going to give you a red mark. We're only going to give you a green mark if you* [sign up]". … And that's an important concern for industry, because what that says to industry is that there is a significant hurdle to using omega-3 from a GM source because they've already given a commitment that they will not use GM canola oil and omega-3 from a GM canola is GM canola oil [Canberra, 17/12/08].

A scientist suggested using bio-fermenters and thought that it was possible to eventually produce long-chain omega-3 oils on a commercial scale if desired.

Interviewee: Why go to the canola state? Why don't you miss it out so it just set up a big fermenter and harvest the algae as they are? There's absolutely no problem with it as long as you left the economic part of it out of it, so using bio-fermenters on a large scale, that's fine. Yeah. So you can take the canola out of the equation and get it straight from the marine micro-algae to the indirect uses or the direct uses. So that's an alternative that's currently happening.

Julie: On a scale big enough to satisfy the markets though in the future do you think?

Interviewee: It all depends on how big the market is and how much people want to invest in the fermentation systems and whether it's economic. So there are a number of factors that need to be considered, and at the end of the day, it will be an economic issue more than a biology issue, I think. But if you look at this particular chart including the canola in the flow diagram, the main issue about the canola is where is the canola going to be grown? Is it going to be grown in an environment that is an acceptable environment from a regulatory system? You know, with all the things to deal with, contamination, supplier chains ... are there going to be GM and non-GM supply chains? And all those associated issues to deal with GM versus non-GM products. … There's already commercial companies that use micro-organisms in fermentations systems to produce omega-3. So there are non-GM approaches that are currently being exploited and they could be enhanced or improved on, or just more of it, more of that technology as opposed to GM [Hobart, 14/11/07].

Other public participants also wanted to see alternatives.

I would still like to know if there was another source besides this for omega-3. Telling people who took fish oil capsules "now that's out because there's no fish, now you are going to [use] say canola", so that's the next fashionable thing. So you know, I still would like to see something about other sources, lots of other sources [Hobart, 2/10/08].

## Discussion of the case study

There are social groups who will benefit directly from the CSIRO omega-3 technology, particularly if the product is cheaper than fish oil. The aquaculture, livestock industries and oil processors will benefit directly as a cheaper and cleaner source of oil (that is free from pollutants) will give them a marketing advantage over the current source of long-chain omega-3 oils from seafood. This may also reduce the pressure on wild fish stocks if less fish oil is obtained directly from fish, however, it is unlikely to reduce the consumption of fish. Fish oil producers may or may not be affected depending upon future market demand for long-chain omega-3 oils and the acceptance of the CSIRO GM product in the market place and by the Australian publics.

Incorporation of long-chain omega-3 oils into livestock and farmed fish may be a good way of increasing consumption levels, however, this involves intensive farming methods which raise other social issues. Intensive animal farming usually means the use of antibiotics and other preventative disease control measures which were a cause of concern to some participants. These farming methods also increase the likelihood of adverse environmental impacts and can create ethical issues about animal welfare.

Other social groups likely to benefit from and accepting of GM long-chain omega-3 oils were broad-acre farmers who can use the potentially high value GM canola in their current crop rotation. Organic and non-GM farmers may be adversely affected by inadvertent pollen drift or seed co-mixing and potential legal action by biotechnology multinationals, however this would really only be the case if this technology significantly increased the total amount of GM canola being grown, which is unlikely. It is possible but not conclusive that some vegetarians may be willing to consume GM long-chain omega-3 oils, however, this needs further investigation. Environmental groups and people from the medical and nutrition professions were generally sceptical about any GM process (especially involving multiple genes) and raised similar concerns about GM foods such as the need for long-term health assessment and labelling. The representatives from the medical and nutritionists group (unlike the majority of the environmental groups) were not against the omega-3 project *per se* because of the perceived health benefits.

The case study results have reflected a widespread range of concerns about using GM technology in Australia for the similar reasons documented in previous studies, for example, Biotechnology Australia's, *Community Attitudes to Biotechnology: Report on Food and Agriculture Applications* (Eureka, 2007) and a study by Mohr (2007). These include issues such as people's receptiveness to science and technology, trust in various agencies such as biotechnology companies, and general concerns about the industrialisation of food. It is also apparent that there is a level of confusion about the current use of GM food technology in Australia with many people thinking that we are already consuming a range of GM products (Eureka, 2007). Owen (2007) reported that most of the Australian publics are unaware of the nature of regulation and the organisations responsible for controlling the release and distribution of GM organisms, despite the efforts of the government and industry. This work also showed that GM foods that do not offer a benefit will be avoided by the Australian publics unless there is a price discount of between 30 to 60 percent. Overall, the number of social research studies conducted in Australia has been far less than those undertaken in the UK, Canada or the USA (see review by (Costa-Font et al., 2008).

Throughout the research, it was very clear that there was a low level of trust in one well-known international biotechnology company in particular (company X). It appeared that actions of this company increased community resistance to GM foods as a result of an array of media reports of issues that had attracted bad press. Biotechnology Australia reported that the majority (55 percent) of their survey respondents thought that the use of GM in agriculture was mostly for the benefit of companies (Eureka, 2007). Whilst there was generally a good level of trust in food and GM regulators, there was criticism about the independence of food safety testing for GM foods. It was suggested by some participants that long-term health and environmental monitoring should be considered to improve acceptance of GM in the future. This was also the finding of Biotechnology Australia (Eureka, 2007).

Some participants in the case study (including environmentalists) conceptualise risk differently to the scientific community. The reasons for this relate to ethical and subjective viewpoints relating to their social meanings of food. For some participants, the presence or absence of novel genetic material in food products is irrelevant in even highly refined oil products. Another study found that people would avoid or reduce their likelihood of purchasing GM products that had no perceived benefits, even if products only contained a trace amount of GM product (Owen et al., 2005). First generation GM products have reached the marketplace before the potentially more acceptable second generation GM products, which offer a direct benefit to the public. However, this may not hinder the acceptance of the CSIRO omega-3 product that can be viewed as a nutraceutical and/or medicine (as well as a food), which research has shown may increase its acceptability. This has been the conclusion in the study by Biotechnology Australia (Eureka, 2007), however, Cox (2007) found that people susceptible to coronary heart disease did not show an increase propensity to consume GM long-chain omega-3 oils, even after being informed of its health and environmental benefits.

Another concern surrounding the use of GM technology is the potential for adverse environmental impacts. This was mentioned numerous times throughout the case study and is consistent with the findings of Biotechnology Australia (Eureka, 2007). The use of canola as a producer of the long-chain omega-3 oils raised concerns due to its propensity to outcross into weedy species, and some participants presently avoid canola as they think it is already produced using GM technology. Olive oil was cited as being a healthier although more expensive alternative to canola. Cotton posed less of a threat to the environment, as it has a lower chance of out-crossing, however, it places a high demand on limited water resources.

The use of functional foods as a vehicle for the GM long-chain omega-3 oils created concerns because of the highly processed foods to which the functional ingredients are added. It appears that incorporation into functional foods is only likely to reach a small segment of the population because of its comparatively small market share. Incorporation into healthier foods may be a good option to increase the market size.

Other issues revolved around sensory issues of taste and smell and also the cost of animal products and functional foods. Participants mentioned the potential of fishy taste and smell on many occasions with some having had bad experiences with, for example, ‘Up’ omega-3 enriched bread. There are a range of long-chain omega-3 enhanced products on the market, however, according to Cox et al. (2007) some have not been very popular because of sensory reasons. Milk products were suggested as being a good way of increasing the level of long-chain omega-3 consumed, as they are so widely used in Western style diets.

Patch et al. (2005b) attempted to understand the complexity of the decision-making process that people experience when choosing to consume long-chain omega-3 oils enriched in functional foods, which resulted in marketers of these products being advised to change the attitudes and beliefs of consumers about the effectiveness of these products. Patch et al. (2005c) showed that despite participants being aware of the potential health benefits of long-chain omega-3 oil functional foods, they were reluctant to consume them due to fears about overdosing, and cost was also a major barrier. The case study results also confirmed the confusion about obtaining the optimum dose of long-chain omega-3 oils and the costs of obtaining it using direct or indirect methods, and concern about the potential to overdose. There have been reports that the Australian publics are sceptical about such products being promoted predominantly as a marketing gimmick, rather than being beneficial for health (Patch et al., 2005c).

Labelling was an issue for many participants and there was a general consensus that there was room for improvement in this area. Labelling of the GM omega-3 product directly incorporated into capsules and functional foods was desirable by most participants to enable people to make an informed choice. The view that GM foods should be labelled was also reported by Biotechnology Australia (Eureka, 2007). As the characteristics of the oil are significantly altered, it is likely that it would presently have to be labelled by law under FSANZ standard 5.1.2, however, this may change in the future. Incorporation of long-chain omega-3 oils into animal products by feeding livestock or farmed seafood is likely to be more acceptable to those who are uncomfortable with GM foods. Labelling of animal products fed with GM feeds and or transparency on behalf of the aquaculture and livestock industries may still have to be given some consideration. Marketing using either method is likely to be challenging due to the general lack of knowledge about the differences between long-chain and short-chain omega-3 and the associated health benefits of long-chain omega-3 oils.

In hindsight, it may have been useful to have conducted more social research studies using TA tools to ascertain the acceptance of GM long-chain omega-3 oils, and explore other non-GM alternatives before the onset of the omega-3 research. The results of the case study indicated that the use of GM technology may still be a potential barrier to the adoption of the omega-3 product. The results have shown that a non-GM source using bio-fermentors was suggested on several occasions, however, CSIRO and others consider this as being an economically unviable method for large-scale production of long-chain omega-3 oils. The economic imperative may be reviewed in the future in favour of social values as using micro-algae is likely to receive broad social acceptance and avoid the current issues that confront GM technology. This is not to say that GM technology may become more acceptable by a larger proportion of the Australian population in the future, especially for a GM product that provides a direct benefit to the Australian publics as in the case of GM long-chain omega-3 oils.

## Conclusion

The case study identified some of the social and ethical concerns surrounding the use of GM technology in Australia, which are consistent with the limited number of previous studies. The willingness to purchase and consume foods derived from GM technology is complex and the underlying reasons do not necessarily relate to risk *per se* but also reflect subjective views. As the potential omega-3 product provides a direct health benefit to the public, it is more likely to be accepted than first generation GM products. The general consensus was that products with GM long-chain omega-3 oils marketed for direct consumption should be labelled to enable the Australian publics to make an informed choice. It is still to be determined if this would be a legal obligation in the future. This is unlikely to discourage those who wish to increase their consumption levels of long-chain omega-3 oils and may increase the level of transparency and trust particularly amongst sectors of the population that are sceptical about GM products. Some individuals and groups still wish for long-term health and environmental impact monitoring to be undertaken, which may also increase acceptance and bridge gaps that are present due to issues related to the level of trust in, for example, large corporate biotechnology companies.

Functional foods may not be the most effective way to increase the current levels of consumption of long-chain omega-3 oils due to the current small market size that these products occupy and sensory issues, however, both of these issues may be addressed in the future. Incorporation of long-chain omega-3 oils into livestock and farmed fish may be an effective way of increasing consumption levels, however, intensive farming methods raise other social concerns related to animal welfare, the increased use of antibiotics and adverse environmental impacts. The lack of knowledge Australians have about the differences between long-chain and short-chain omega-3 as has been recognised by industry, scientists and others (Turchini et al., 2010), and the associated health benefits of long-chain omega-3 are still barriers to overcome. The public also need to know how to obtain the appropriate intake or 'dose' that is affordable and realise that there is little danger of overdosing on these nutrients.

# Chapter 5. Can Technology Assessment be useful to the Australian food industry?

Technology assessment (TA) has been widely used and successfully institutionalised in many European countries since the 1980s (Hennen, 1999, Genus, 2006). In Australia, it has not been formally implemented or institutionalised except in the variant of health technology assessment, for example the Adelaide Health Technology Assessment Unit in the Discipline of Public Health, University of Adelaide (http://www.adelaide.edu.au/ahta). The Technology Assessment in Social Context (TASC) project was initiated in 2006 to develop a TA framework that would be effective in Australia, and to devise a new form of TA which focused on the social context. It also looked for potential ways in which TA could be usefully applied and potentially institutionalised in Australia (Russell et al., 2010). TASC defines TA as "an applied process that considers the societal implications of technological change in order to influence policy to improve technology governance" (Russell et al. 2010, p109). The proposed TASC framework developed by Russell, Vanclay and Aslin consists of a stepped process of:

- Scouting – identifying emerging technological developments in the pipeline.
- Screening – selecting and prioritising technologies for assessment based upon criteria such as its potential to have a high social impact (magnitude and distribution), where outcomes may be uncertain, or where there is likely to be community concern.
- Scoping – conducting a preliminary assessment to frame the topic, its purpose, the methods that should be used, stakeholders and resources needed.
- Assessment – of the potential social consequences associated to a particular technology.
- Communication and participation – Facilitating multi-way communication between all stakeholders.
- Evaluation – reflection on the process, methods, content and outcomes (ongoing learning).

This PhD is only part of the overarching TASC project and the research question for the PhD is – how can technology assessment (TA) be useful in the food industry? The potential application of TA has been investigated by undertaking a case study on a food technology being developed by the CSIRO Food Futures Flagship: the omega-3 project. The main aim of the CSIRO omega-3 project is to produce a sustainable plant land-based source of omega-3 long-chain polyunsaturated fatty acids to supplement current fish oil sources (Nichols, 2004, Nichols et al., 2010). These nutrients are synthesised by marine micro-algae and passed up through the food chain. This project has the potential to reduce the pressure on wild fish stocks and increase the availability of long-chain omega-3 oils for human consumption. The omega-3 project involves the development of genetically modified (GM) oilseed plants using genes sourced from marine micro-algae. GM technology has created controversy in some countries, for example, Europe and its acceptance by the Australian publics is important if this technology is to be successfully embedded into society.

In this chapter, the responses of the interviewees about the concept of TA are presented. The different types of TA and the tools available are briefly outlined and some issues that may be associated with its implementation and practice. This is followed by a discussion of the types of TA and potential ways it may be institutionalised in Australia by particular sectors of the food industry. The experience gained through the conduct of the case study and lessons from a similar initiative undertaken by a scientific organisation developing GM grapes in France are discussed.

## Comments from case study participants

In Chapter 4 the responses of the case study participants were presented that reflected views about the CSIRO omega-3 project. In addition, key informant interviewees were asked what their thoughts were about the potential usefulness of TA in the food industry. The results of the case study reflected a high level of support for a technology assessment process in the food industry from most social groups. The main concerns related to the cost of conducting TA, who would be responsible and how robust it would be against market forces.

Some comments related to the application of TA to agriculture.

> The introduction of new crops, by and large, not a lot has been done, but people have gone for new crops because the greater productivity, I can make more money out of this, or it's better suited to wetlands, dry lands, or whatever it is. And by and large, decisions have been made by other farmers, the aggies (meaning the staff from the Dept of Agriculture), without necessarily thinking too widely about the bigger picture and the potential impact. The classic example … in the longer term would have been the – not the dung beetle, but the cane toad [Hobart, 24/09/07].

Environmental groups were generally enthusiastic and quite knowledgeable about the concept of TA. Some thought that TA should be initiated early in the development of a technology and should entail a process where a broad range of stakeholders could be involved.

> There's all sorts of models [that] could be developed. There's no interest in it at the moment because any attempt – because groups like the CSIRO and FSANZ have shown how contemptuous they are of any public involvement and public opinion full stop. And we see this with GM labelling. You know, for many, many years … the public has overwhelmingly been asking for labelling of GM foods, and time and time again FSANZ ... revisits the issue and denies us GM labelling and misleads the public at the same time by making them think that we do have GM labelling when we quite clearly do not. And that shows even the most basic of questions which, when they've bothered to ask people about technology development such as GM – when they ask the question and they don't get the answer they want, well they just ignore it. So I see them as utterly contemptuous of the public in that sense … We are looking to develop models for technology assessment in Australia and we're still working on that, and there's been some attempts at that in other countries. … I take it to mean … in its most basic form, that we assess technologies before they actually get rolled out ... at the early innovation stage, and that they be assessed for a whole range of issues. And there's obviously a million ways of assessing that – who gets asked, but we're looking for more democratic models of technology assessment which doesn't just include experts and industry people and government people, but also a whole range of stakeholders, and that means, you know, getting some public participation and public involvement in that process. So that's all fairly broad, but … I think we live in a technological society and we have been for many decades and it's incredible how little we reflect on this technological development, and of course we're not encouraged to because governments – and we see this with nanotechnology now and genetic engineering – governments see this as the next big thing in terms of economic development and new products and commercial applications and they're not really interested in technologies assessment because they would see it as slowing down, halting, putting constraints across [Melbourne, 24/09/08].

Other environmental group representatives were sceptical that it could be implemented.

> Look, I think it's a great idea theoretically. But call me a cynic, and this is no reflection on UTAS or your program, but I'm highly sceptical of, you know, scientific assessment of environmental, social and economic impacts because it is

repeatedly abused. Whether it be, you know, the assessments that we have to deal with which is, you know, pulp mills and logging and so forth, or whether it's … politicised, whether it's corporatized, … it's [the] big … [Company Xs] and so forth who have vested interest in making sure that the environmental, social and economic impacts are seen to be minimal. So, I think it's great, but unfortunately in the current highly politicised, … vested interest economies, I'm highly sceptical of it [Hobart, 07/08/08].

A scientist commented.

> Well, the only thing that comes to my mind is the fact that probably people should be informed better about all the new changes in the food industry, in novel approaches in the food industry, and it should be delivered in a way which is understandable to people. So otherwise it will not hit the target, and people will still hate the genetically modified food, or all these changes made by scientists because they just don’t understand what is going on. And they are scared of any changes [Hobart, 20/09/07].

It was also thought that TA should be conducted before research funding was granted.

> Well, I mean, I think it should be a part of every research application before it even gets funding. I mean, I think it should be … part of the basic thought processes before anybody spends any money … [The] Fisheries Research Development Corporation … invite grant applications … for CSIRO for example. There’s a justification part of that application which seeks to identify a whole range of benefits that may come from that project if it were successful. It’s never been well done. I know this because I’ve done a lot of cost benefit analyses using these things. But there is an attempt, at least, to try to extract from the proponents what they think might be the main benefits, and the risks. But to see it in a more structured way would be ideal [Hobart, 30/07/08].

A major food company representative was receptive to the idea of TA to address more of the social and environmental impacts.

> Julie: Do you think that [TA] would be useful to apply in the food industry?
>
> Interviewee: It certainly would, yeah. I mean any time when you can buy people in earlier into the project or … whatever you’re going after, then usually in my experience the better the outcome. And you’re not open, as I said before ... the heretics and the radicals out there saying that you’re trying to hide something or you haven’t involved them, or you’re running off on a tangent, they’re all seriously deluded people, all of that sort of thing.
>
> Julie: So do you think companies like this would be interested in developing the technology assessment side of it more? To include more of the potential social and environmental impacts?
>
> Interviewee: I think most food companies, certainly the larger ones, are you know lifting their radar in terms of the, you know, socio-economic aspects of their businesses, and so technology is part of that [Mentone, 25/09/08].

A representative of a health organisation commented.

> Julie: And what do you think about that [TA] as an idea?
>
> Interviewee: It sounds very sensible to me, it’s like the sort of advocacy we do here. We’re often asked about so called carcinogenic effects of this and that and the

other, and we can only respond in so far as the science informs us, and in so far as something is not scientifically demonstrated and proven, we can't advocate it. So people will often come to us and talk to us about alternative therapies for example. Now, alternative therapies actually can be split into two. If they're complementary … and if there's been something that's proved to be negative about them we'll say: "*feel free to choose that, but do keep your doctor informed and do be very aware of what you're taking and research it thoroughly*". If you're suggesting that you replace traditional therapy with alternative therapies that are not yet demonstrated [to be effective].

Julie: Well this [GM omega-3 product] could be seen as an alternative therapy, I guess. How would people with cancer feel about taking something like this?

Interviewee: I would imagine not all but most people with cancer are very willing to try something that, as far as they are aware, does no harm and may have benefit. And you see that all the time, you see them going on funny diets or meditating or thinking positively or going for biofeedback, and who knows whether it helps or not? And that's the problem. So we advocate sensible use of complementary therapy but we do not advocate in any way replacing traditional therapy with stuff that is unknown. If people want to do it, they should feel free, but we're not going to say, "it's a great thing to do", we're going to say "whatever suits you is the way to go". So in terms of these sorts of food, if you follow your technology assessment and it comes out at the end that all this was a waste of time, that's a bit of a bugger because the money would have been spent anyway. But if you do this and you don't have a technology assessment, then ethically there's a real problem with it because you haven't completed the cycle.

Julie: Spending public money?

Interviewee: Not only that, but you're also in danger of doing harm inadvertently obviously that then costs a large amount to fix and probably takes a long time.

Julie: Losing people's faith and that kind of thing?

Interviewee: Yeah, that's right. So I think that both ethical and very good commercial reasons to follow technology assessment line, but it implies quite a lot more cost. I have no idea, but I would imagine it would at least triple the cost of anything that you were doing.

Julie: But then it's not cheap to do this sort of research.

Interviewee: No, and it's also not cheap to go back and say "oh dear, we screwed that up". Well okay that was 10 years ago and we've got 10 years worth to deal with and the some syndrome, all that sort of stuff backs that up. You've just got to be really, really careful when you're playing with genes – well with food [Hobart, 18/07/08].

A TA practitioner commented.

The big thing about any technology assessment is it's expensive, it's time consuming. You need someone who wants to pay for it and that's a vested interest issue. And so government's not paying for it, who's paying for it? So ultimately it's government really that you know, you need to have pay [for] it. How to implement it? My goodness! I think that's just too huge a question. … And I think the social implications, they just get buried constantly. And I think they're very important. And with a lot of these sort of technologies, they're not important until they affect you. And once they start affecting you, then you become more interested and they are important [Melbourne, 24/10/07].

A social commentator also expressed scepticism.

> If it's rigorous enough, I think it will be good, but I think the trouble is … I get the personal feeling, market forces, huge manufacturing concerns, employment processes, government concerns and massive bylaws are going to make it really difficult [Hobart, 10/10/07].

## Summary of the results from the case study

The results of the case study showed that many participants from a range of backgrounds supported some type of TA system in the food industry. Potential applications ranged from, for example, agriculture where it could be used to broaden the stakeholder input into decision-making, and consider the 'bigger picture' of potential long-term impacts rather than just short-term economic gains.

Environmental groups were particularly passionate and generally quite knowledgeable about the application of TA to the extent that one group is also attempting to develop a model themselves. They were doing this because they perceive government agencies such as FSANZ as not doing enough to engage the Australian publics and are frustrated as they feel their views are ignored. They are seeking a system where the Australian publics are involved early on in the development of a new technology.

It was also suggested by some scientists that the Australian publics can be 'scared' about novel technologies that enter the marketplace, and suggested that TA may be a useful method to relay information about scientific innovations in a language that the Australian publics can understand. Other participants also thought that a TA process should be initiated when funding applications were being considered as a pre-requisite for funding approval. This would maximise the potential for the Australian publics's money to be spent on technologies that are more socially acceptable and help avoid inadvertent impacts that may be expensive to rectify. A TA system was seen by some participants to be a more ethical and democratic way of introducing new food technologies. A major food company that has currently conducted market research on its food products, also expressed interest in a TA system to help deal with public opposition and take social factors in to account.

Some participants were sceptical about the potential for a robust system of TA to be implemented due to a number of perceived barriers. These included concerns relating to the political nature of technological development and the power of commercial forces in the marketplace coming from government and multi-national corporations, which may dominate over other groups and prioritise economic gains over social issues. There were concerns about who should fund and conduct the TA, which may be an expensive exercise.

In summary, the results of the case study reflected a high level of support for a technology assessment process in the food industry from most social groups. The main concerns related to the cost of conducting TA, who would be responsible, and how robust it would be against market forces. This raises the question: which type of TA is the most appropriate for different sectors of the food industry?

## Types of TA and some issues associated with its implementation and practice

There are many different types of TA (which have been described in detail in Chapter 3) that have evolved according to the political context, its purpose and the audience. The main characteristics of TA involve forecasting and monitoring the impacts of emerging technologies on society. The early forms of TA tended to be technocratic and expert-based, however, later versions aimed to broaden the range of social groups that could influence technology development. Interactive TA (Grin and van de Graff, 1996) sought to promote interactions and communication early in the innovation process. This type of TA has been trialled by the French National Institute for Agricultural Research (INRA) to address growing public concerns surrounding the introduction of GM grapes (Joly and Rip, 2007, Marris et al., 2008). Constructive technology assessment (CTA), which is still being developed in European countries, aims at forming an arena where society can interact with technology developers at an early stage to enable a process of co-creation CTA (Schot and Rip, 1996, Genus and Coles, 2005, Genus, 2006). In 2003 CSIRO initiated a Social and Economic Integration (SEI) to focus on incorporating opportunities for cross-disciplinary and

multi-stakeholder engagement to foster, for example, community driven science solutions and socially informed technology design.
(http://www.csiro.au/proprietaryDocuments/SEI_Research_Priorities_Fact_Sheet.pdf)
The SEI seems to have been dissolved in later years, however, due to numerous structural changes it is not clear if this initiative continued in another form.

Developing a TA framework that is usable in a particular social and political context using any type of TA is a challenging exercise and there are still issues that need to be addressed. The Flemish Institute for Science and Technology Assessment is one example of a group that have reviewed and analysed the potential use of TA in Flanders. The Technology Assessment – Methods and Impacts group's mission was to explore what impact TA may have on policy-making, and the effect it should or should not have on decision-making, and its ability to influence the path of social and political debate on technology issues (Hennen et al., 2004). They found that there was very little work to date on how to measure and evaluate the impacts of TA in Europe. They identified some of the difficulties associated with achieving TA objectives mainly aimed to support policy-making, for example, how to fill in knowledge gaps regarding policy options and uncertainty about scientific data, and how to facilitate communication between stakeholders in deadlock situations. Different tools can be used to address some issues such as forming visions or scenarios that can be used to stimulate further debate or encourage particular actors to be more self-reflexive.

Developing a TA process can be fraught with difficulties due to differences in power between different groups. Scientific knowledge can be filtered so it can be used strategically during the process of negotiation according to the values, beliefs and desires of a dominating group (Hennen et al., 2004). This can lead to changes being made to the structure of the debate and open up the policy-making process by inducing new options. Other influences on the TA process can be unpredictable, for example, media press releases that raise the attention on particular scientific issues. This can be constructive in that it places pressure on policy-makers to be receptive to the publics' views (Hennen et al., 2004).

Genus (2006) reviewed selected literature related to the notion and practice of CTA as a potentially constructively democratic, reflective and discursive process. This work reflects on the inequalities of access to and control over technological decision-making processes by particular groups and the need for groups must be open to criticism in order to produce reflective techno-scientific experts (Genus, 2006). Caution is also raised over the exclusive reliance on government-based participation processes (legitimated systems of CTA), stating that ways of gathering commentary from a broad base of lay groups and individuals needs careful consideration. It was deemed important to ensure that interest groups and citizens have the capacity to probe the claims of particular assessments and to encourage wider debate and self reflection of all actors (Genus, 2006). One example Genus and Coles (2006) refer to is the GM Nation initiative, where a national debate as to whether GM crops should be commercialised in the UK was criticised as failing to cater for the public's opinion and being an information giving exercise that reinforced the 'deficit model'.

There is no one particular type of TA that fits all actors in a particular agency or country. Different types of TA are still evolving and are still in the early stages of development. There are many challenges to overcome these issues and implement a system of TA that is appropriate for the Australian social and political context. There are three layers of government federal, state and local, and there are enormous arrays of actors and agencies involved in the food industry starting from the decision-makers who decide which food technologies should be researched, through to the public health sector who have to develop policies to deal with any subsequent health impacts. In between these beginning and end points are the primary industries, food processors and manufacturers, retailers, food regulators, and many more. This raises the challenge of not only which type of TA would be suitable for a particular context, but which type of agency should or would be interested in institutionalising a TA process?

## Discussion of the types of TA and potential institutionalisation in Australia

Some initial thoughts were that particular types of TA could potentially be institutionalised in a number of agencies in the food industry, for example, multi-national food or biotechnology companies, scientific organisations (e.g. CSIRO) and research funding bodies (e.g. Australian Research Council), or as an independent advisory organisation potentially funded by government. The possibility of initiating a system of TA accreditation was also considered.

There is increasing pressure on multi-national food companies, which control so much of the food supply, to be aware of triple bottom line principles and address social and environmental as well as economic impacts. Over the last few decades some food chain operators have been confronted by the public, NGOs and governments with various concerns. These include the generation of externalities (economic and social costs) that the contemporary food supply chains are causing, namely in terms of health, due to diet-related non-communicable disease (Barling, 2007). A report describing a range of TA tools has been prepared by the Agricultural Economics Research Institute in the Netherlands, titled *Ethical Bio-Technology Assessment Tools for Agriculture and Food Production: Final Report Ethical Bio-TA Tools* (2006) (http://www.ethicaltools.info). Within this report is a Corporate Moral Responsibility-kit, which outlines TA tools that can be used and provides a suggested framework to assist corporate companies raise their social responsibility profile. The aim of this is to develop a mutual understanding of the concerns, values, interests and differences between corporations and stakeholders. Some companies such as Unilever have already conducted work on how to achieve agricultural sustainability and assist local communities (Pretty et al., 2008). A representative of a major food company in the omega-3 case study also showed interest in TA to address triple bottom line issues. It is possible for companies to have their own TA units, however, it remains to be established if this would be the best path to take, or whether an independent TA unit would be a better option.

## Scientific research institutions: Lessons from France

The National Institute for Agricultural Research (INRA) in France has been developing an interactive TA (iTA) framework to address the social and political issues surrounding the introduction of GM disease resistant grapevines (Marris et al., 2008). INRA is a substantial scientific organisation which conducts scientific work widely perceived as being for the public good (similar to CSIRO in Australia). Since its creation in 1946, it has interacted with organised bodies in the agricultural sector. In the early 1990s, the role of INRA became controversial after various agricultural and/or food related crises occurred, for example, bovine spongiform encephalopathy (mad cow disease), which had detrimental environmental and health impacts. This was exacerbated by the controversy over the proposed use of GM technology in agriculture and food, which emerged in 1996. The institution was criticised about its research orientation and increasing collaboration with the private sector, challenging its position to promote the public good. INRA initiated an iTA process which aimed to create a co-constructive arena for the research program trialling GM disease resistant grapevines, a crop of great cultural significance. To form a working group of 14 people, the project leaders invited participants from ‘ordinary’ backgrounds rather than leaders or spokespeople of specific groups. Participants included researchers, laypeople, vine growers and workers who were brought together to establish a group who were representative of the outside world to debate the appropriateness of conducting the GM grape trials. Intensive discussions taking several days were conducted over a six-month period. In addition, 40 interviews were conducted with a similar group of stakeholders in the wider world to ascertain, for example, their attitudes to GM techniques, perceptions of the wine industry and opinions towards INRA (Joly and Rip, 2007, Marris et al., 2008).

INRA found that the exercise led to a microcosm that separated the iTA exercise from the wider world outside by creating an extra public arena where sociotechnical controversies are carried out, rather than creating the ideal conditions for public debate (Marris et al., 2008). The exercise actually enhanced controversy by giving the impression that INRA was trying to manipulate public opinion rather than engaging in real public debate. They recognised a trade-off between increasing legitimacy by involving representatives from formal constituencies, which led to more bargaining instead of deliberation, and using a small number of ordinary people which fostered collective learning at the price of lower legitimacy (Marris et al., 2008). The whole exercise did promote internal learning and changed the way INRA managers approached decision-making on research programs by realising the importance of opening up choices about some of its research to external stakeholders (Marris et al., 2008). Another outcome was the creation of a local steering committee in the area where trials were to be conducted to provide feedback on the field experiments to INRA. This committee grew to become a forum for debate on various research options (Joly and Rip, 2007). The main lesson was the realisation that public consultation in science and technology is needed early enough to enable the development to change course (Joly and Rip, 2007).

The experience reported by INRA and the case study of the CSIRO omega-3 project have some elements in common as both involve GM food products. The INRA disease resistant grapes was a first generation GM technology, whereas the CSIRO development is a second generation technology. Both studies were conducted by the scientific organisation developing the product (although more indirectly in the omega-3 case study), with INRA's project being at the field trial stage, whereas the CSIRO project was at the proof of concept stage.

INRA experienced a backlash from the public who viewed them as trying to promote the product. For the omega-3 project, there was a greater degree of independence due to affiliation with the University of Tasmania (UTAS), however, as I presented an overview of the technical aspects of the omega-3 project during interviews and at the beginning of focus groups using a poster with the CSIRO logo, some participants were of the view that I was working on behalf of CSIRO (even though I made it clear that I wasn't). This occurred in some cases even after information sheets stating that I was a UTAS student, were read and signed by each participant. Throughout the conduct of the case study, this was not a major issue as CSIRO seemed to have a high level of trust with the majority of participants. However, this may change in the future especially if CSIRO source more funding for research from industry. The experience gained through the conduct of the case study and reflections of the interactive TA conducted by INRA in France, indicates that the independence of the TA practitioner needs to be carefully considered. In hindsight, it may be safer in circumstances where controversial technologies are being developed, if the TA practitioner is independent from any particular agency to minimise any similar backlash that could arise due to differing levels of public trust.

The type of TA process initially conceptualised for the case study was intended to be an interactive or constructive TA. The concepts of the CSIRO omega-3 project were initiated in 1997, which was approximately six years prior to the commencement of the actual research. CSIRO held several informal iterative exercises with a range of stakeholders during this stage, however, the research was well underway during this particular case study. The trajectory of the omega-3 project's research and development could not be changed meaning that a constructive TA was not possible. CSIRO have a comprehensive website that enables the Australian publics to access information about the Flagships and provides an outline about specific research projects and published reports (http://www.csiro.au). Interested publics can contact CSIRO via their communications department who can direct questions to a specific person in the organisation. At times questions cannot be answered if they refer to sensitive issues that pertain to confidentiality agreements with, for example, biotechnology companies. Some participants in the case study mentioned that they personally found it difficult to obtain technical help from CSIRO.

In the future, CSIRO could introduce a TA process to improve on their current informal system of assessing the potential social consequences of new technologies. If the TASC framework was followed, technologies that may lead to public concern or have the potential to have unintended social impacts would be identified. A CTA process could then be initiated that could minimise or mitigate issues, enhance learning and communication between the scientists and society, and enable the trajectory of a technology to be changed if necessary.

The objectives of the overarching ARC TASC project were to review international best practice and establish a set of quality criteria for TA. This information is in the process of being published along with a number of TA-like activities that have been conducted in Australian institutions. The conclusion was that a good TA needs to be systematic, broad, inclusive and well resourced. By this Russell et al. (2010) describe good TA as being:

> systematic in the sense of being rigorous, reflexive, informed by existing theory and practice, and employing formal mechanisms of quality control. Good TA is broad in terms of disciplines, topics and perspectives and integrates information from multiple sources. It is inclusive in facilitating participation of a wide range of relevant actors in ways that are deliberative, engaging and transparent. Quality in TA is only achievable with adequate resources and time. In addition to these method characteristics, TA can be judged by impact criteria, including the trustworthiness of the TA organisation, which should be reputable, independent and multipartisan; and the influence of the organisation on policy, opinion or action through links to decision-makers and good communication.

A formal TA agency in Australia similar to those in Europe could improve technology policy and governance. This would improve upon the current fragmented, uncoordinated and variable quality TA-like activities that have been conducted in various Australian institutions.

## Conclusion

Most of the participants in the case study showed a high level of support for a technology assessment process in the food industry. The main concerns related to the cost of conducting TA, who would be responsible and how robust it would be against market forces. This raised the question: which type of TA could be the most appropriate for different sectors of the food industry? Multi-national companies may be willing and able to initiate their own system of TA to address triple bottom line issues and increase their level of trust with the broader community using established guidelines reported in the *Corporate Moral Responsibility kit* developed by the Agricultural Economics Research Institute in the Netherlands. It was suggested by one case study participant that a TA process should be initiated as a prerequisite to obtain research funding, however, the potential for this needs to be further investigated.

INRA conducted a TA mid-way through a research program developing GM grapes. One of the main lessons learnt was that public consultation in science and technology is needed early enough to enable the development to change course (Joly and Rip, 2007). CSIRO presently engage with stakeholders who have contact with the Australian publics prior to the initiation of a particular research project. This process is conducted in an informal manner. The utilisation of a TA framework would make it a more robust procedure. A TA framework such as the one suggested by the TASC team could be useful to scope and screen for research projects that may be contentious, likely to affect a sizable proportion of the population or raise other issues relating to social, ethical or legal matters. Consideration needs to be given as to whether some institutions should initiate and conduct a TA, or contract a more independent TA practitioner. A formal TA agency in Australia similar to those in Europe could improve technology policy and governance. This would improve upon the current fragmented, uncoordinated and variable quality TA-like activities that have been conducted in various Australian institutions. The results of the TASC team can be found in the recent paper by Russell, A.W., Vanclay, F., Salisbury, J. & Aslin. H. (in press) "Technology assessment in Australia: The case for a formal agency to improve advice to policy makers", *Policy Sciences* (letter of acceptance 12 July 2010). DOI 10.1007/s11077-010-9120-4. The work by Russell et al. (2010) has identified the quality criteria that would characterise a good TA as being systematic, broad, inclusive and well resourced.

Another consideration is whether the government should be responsible for implementing and conducting TA. In the past, this has created some difficulties in Europe, for example, the GM Nation exercise undertaken in the UK. Many other European countries, however, have strong and robust TA processes. There is the option of establishing an independent TA unit of expert TA practitioners who could be commissioned by various agencies including the government. There is also the possibility of implementing a system of TA accreditation that could be investigated further. Overall, TA is still evolving and there is no one way of conducting or institutionalising it in the Australian food industry, however, it is clear from this research that it does have the potential to enhance democratic principles and citizenship by increasing the influence of a broader range of social groups in decision-making processes at all levels of food policy.

# Chapter 6 – Conclusions and Recommendations

This PhD has contributed to the discipline of food policy by examining the potential of technology assessment (TA) as a system that can be used in the Australian food and biotechnology industry. Policy-makers face an array of challenges about how to regulate the Australian food industry as new food technologies can enter the marketplace without sufficient consideration being given to the social, ethical and legal issues. This can mean that they fail to become embedded into society. Another challenge relates to the enormous number of actors and agencies throughout the food-chain located globally, nationally and locally ranging from scientific organisations, manufacturers and processors, retailers and marketers. The Australian political context means that policy-making has to be initiated and implemented across federal, state and local tiers of government who are in office for a potentially short period of time. The complexity of this context also means that duplication and fragmentation of agriculture, food and nutrition strategies has occurred across government agencies.

Communication between science and society can be difficult but is necessary if public trust in agencies – whether they are science, government, or private corporations – is to be achieved and maintained. Risk is conceptualised differently by different social groups (Hauge Madson and Sandoe, 2005). Scientists usually assess risk using objective measurable criteria that are only decipherable to other scientists (Raybould, 2007). Objective information often forms a hegemonic source of expert advice for policy-making to the omission of subjective views.

If the Australian publics were engaged during the early stages of decision-making, then funding for research and development into new technologies and levels of public acceptance may be enhanced. The production of a knowledge-base that encompasses the subjective thoughts of a wide range of social groups along with the appropriate level of objective scientific knowledge would greatly assist decision-makers across all levels policy. TA offers a systematic process for addressing some of these policy-making challenges. TA is used extensively throughout Europe to identify potential controversial technologies and mitigate concerns and problems that may affect particular social groups, which may entail changing the structure of agencies or introducing new legislation. There are many tools that have been developed that can be used to produce a systematic TA framework that can be adapted to a particular social and political context. The primary research question of this thesis was: how can TA be useful to the Australian food industry? This was examined by undertaking a case study on the CSIRO omega-3 project. The results of the case study demonstrated that most case study participants were interested in the use of TA in the food industry if a robust and democratic system could be implemented.

This thesis has focussed on the issues pertaining to the use of genetically modified (GM) technology in Australia, which now has extensive areas of GM canola as well as GM cotton. GM food technology has been a source of controversy in some countries, for example, in Europe (Marris et al. 2001). The results of the case study successfully identified a number of issues that still need to be addressed which centre around GM technology *per se*. The work undertaken by Biotechnology Australia demonstrated that Australians are still confused about the use and regulation of GM products (Eureka, 2007).

This thesis has analysed many of the reasons why GM crops and foods created so much attention and concern as opposed to foods produced using conventional plant breeding methods. New food technologies designed to alter the way food is traditionally produced, processed, purchased or consumed can evoke a range of emotional responses. One of the reasons for this is that food forms a central part of our everyday lives and is associated with a variety of social patterns that give meaning to our everyday life. It is also central to our cultural identity and sense of place which determines what we eat and the social context in which consumption occurs (Lupton, 1996). Some reasons why GM food creates concern relate to the level of trust in those that create, produce, control and regulate our food. Many multi-national corporations have a disproportionate share of control over particular sectors of the food industry and can be regarded as being beyond the control of governments (Kellow, 2002). Monsanto, for example, is the largest biotechnology company owning 90 percent of the GM crop market (Foster, 2008). Company-based research is traditionally orientated towards profit-making and can be shrouded in secrecy (Caldart, 1983). An increase in industry funding in the public science research agencies is a source of concern and scientists are urged to exercise ethical caution to ensure that science is still for the public good (Early, 2002, Nestle, 2007).

The other question posed in Chapter 2 was “do GM crops pose a greater threat than non-GM crops to the environment or health?”. The literature review pertaining to the potential issues of mainly first generation GM crops in Australia also raised the issue about how much science is enough science for the purpose of decision-making during the policy process. The appropriate amount of scientific monitoring in Australia still has to be ascertained and there is disagreement in the scientific community globally that GM crops pose a greater threat than, for example, herbicide tolerant non-GM canola. Until the moratoria were lifted a few years ago in Victoria and New South Wales allowing GM canola to be grown, cotton was the only large scale commercially grown GM crop in Australia. There appears to be very little monitoring of GM crops overseas to help determine the most appropriate level of scientific monitoring necessary to protect the environment, however, it is apparent canola has to be properly managed because of its propensity to outcross with closely-related species to minimise environmental impacts caused by the development of herbicide resistant weeds. It has been suggested GM canola should only be used as part of an integrated weed control program and that there should be a minimum time limit between successive GM canola crops (Scholz, 2008). Perhaps government regulators should have a wider portfolio that can include environmental monitoring.

A main concern is the potential for negative social impacts caused by litigation processes that could be undertaken by biotechnology companies. The current regulatory system does not cater for inadvertent co-mixing of GM and GM-free crops either through pollen drift or seed spillage. Deakin (2008) suggests that there needs to be legally enforceable crop separation distances and a compensatory system established to mitigate any economic loss incurred by GM-free farmers. The use of GM technology or crops derived from conventional plant breeding methods may be irrelevant *per se,* if we reconsider the impacts of the overall farming system based upon the large scale use monocultures that generally require high inputs of water, fertiliser and pesticides. Perhaps a realignment of the plant breeding selection characteristics is most needed to favour crops that require low inputs and have higher nutritional qualities such as the ability to sequester micro-nutrients that are lacking in our diets.

GM food safety testing is based upon the scientific determination that it is not substantially different from foods derived from conventional plant breeding methods. The broader community may also be equally unaware of the techniques used in conventional plant breeding, and the changes to metabolic components of food resulting from any plant breeding method have received very little attention. Carmen (2004) has recommended that independent epidemiological testing be undertaken for GM derived crops in Australia. A process of post-market surveillance has been developed in Europe to serve as a back-up to pre-market safety assessment and could also be a tool to assist in the evaluation of public health targets (Hepburn et al., 2008). These are concerns that still need to be revisited in the future as independent safety testing is likely to increase the price of foods, however, some may still consider it desirable for peace of mind and as a way of increasing trust and transparency in government regulators.

Dryzek (2009) analysed the type of deliberative exercises that have occurred worldwide centred on GM foods and how governing elites guide the public through deliberative processes to achieve an outcome that reflects the worldviews of the organisers of those processes, which he thinks are skewed in favour of pro-GM governments that seek a pro-GM consensus. The Canadian and the US government adopted an unshakable commitment to GM whereas Australia was amongst the group of countries that made some reluctant concessions to reflective public opinion. The other literature reviewed in Chapter 3 reinforces the views of Dryzek. It may be pertinent to reassess the future of food production in Australia as we are still locked into a food production system that prioritises economic values above social and environmental considerations.

Technology vision assessment has the potential to enhance reflectivity and change existing technological paradigms which have become entrenched into a particular social and political context. It has been suggested that this could be used to create a new long-term vision for the future of food in Australia. This may mean the revision of the present plant breeding selection criteria (regardless of GM or non-GM methods) and farming methods used based upon monocultures bred to yield with high inputs of fertilisers, pesticides and water.

There is a range of alternative ways of producing food such as community gardens or organic farming that could be used to reduce level of resources currently used in the food industry. There are also alternative ways of purchasing fresh foods direct from the farmer or via farmers markets. There has been very little work to assess what the Australian public's preferences are regarding food policy. One survey conducted at a large farmers' market concluded that people wanted policies that would improve information about the food production attributes, for example, the use of growth hormones, free range and whether animals were treated humanely, and how environmentally-friendly are the methods used (Umberger et al., 2008). Presently there is a duplication of strategies for food between government departments and most of these prioritise economic values above others. Governments tend to be in office for short terms only, making it difficult to achieve a whole of government approach to develop and implement long-term strategies. A whole of government approach is needed to identify the most appropriate research to embark upon, and which could be monitored for any unintended long-term social impacts. In other words, a 'from the boardroom to the grave' strategy which starts with food research and development policy through to public health policy. A vision assessment exercise would provide an opportunity to inform the Australian publics about the range of plant breeding and food production methods available and debate options for the future. It is possible to use tools such as scenario building to debate and create new shared visions for the future or ethical matrices which have been used in India, Europe and New Zealand.

## The case study of the CSIRO omega-3 project

The primary research question of this PhD was - how can TA be useful to the Australian food industry? This was investigated by conducting a case study on an emerging food technology being developed by the CSIRO Food Futures Flagship.

This technology involves the use of genetic modification to develop oil seed plants that can produce essential long-chain omega-3 oils normally sourced by consuming seafood. Social groups that may be affected directly or indirectly were identified and contacted for an interview, or asked to participate in a focus group. The reactions, thoughts and feelings of the participants as captured in this thesis are to be reported back to CSIRO.

As the CSIRO omega-3 project is a second generation GM technology that would directly benefit the Australian publics by offering what is basically a nutraceutical or a food ingredient that can assist many health related illnesses, it was anticipated that it would be accepted by most of the participants. The CSIRO omega-3 project has the potential to provide a sustainable land plant-based source of long-chain omega-3 oils which would supplement the current fish-based source of these nutrients. This could reduce the pressure on wild fish stocks which are the traditional source of omega-3 and which are used extensively by the aquaculture industry. The results showed that there are still some groups in society who are reluctant about the use of GM techniques for the production of food for many reasons. These findings generally concurred with previous studies which identified reasons related to the lack of trust in large biotechnology and food companies and that were considered to be promoting this technology for purely economic gain. Other reasons were based upon, for example, concerns about unintended long-term environmental and health impacts. Overall, groups that were most likely to benefit economically, such as broadacre farmers, were in favour of GM. Other participants were likely to use the long-chain omega-3 GM oil if it were labelled, as the issue of informed choice was particularly important. As there is no such thing as a homogenous public, the results reflected a diversity of opinions. However, the results clearly suggested that many participants were concerned about GM technology.

Functional foods may not be the most effective way to increase the current levels of consumption of long-chain omega-3 oils due to the current small market size that these products occupy as well as sensory issues revolving around potential fishy odours and taste however, sensory issues may be addressed in the future. Functional foods are likely to more expensive which could mean that lower socio-economic groups who are likely to be the most deficient in these nutrients will still be disadvantaged. Incorporation into livestock and farmed fish may be an effective method of increasing consumption levels of long-chain omega-3 oils but again the cost would determine which social groups would be able to benefit. Intensive farming methods may generate other social concerns regarding animal welfare, increased use of antibiotics and adverse environmental impacts due to pollution. The lack of knowledge Australians have about the differences between long-chain and short-chain omega-3, and the associated health benefits of long-chain omega-3 is still a barrier to overcome. The Australian publics also need to know how to obtain the appropriate intake or ‘dose’ that is affordable and realise that there is little danger of overdosing on these nutrients.

I think that there is a need to find ways to communicate information about GM technology, but at the same time to foster an iterative and interactive arena where facilitated dialogue can occur to maximise learning and increase understanding between scientists and social groups. The process of scientific communication with the Australian publics that CSIRO undertakes prior to and during a particular research project was not examined in this thesis, but this may be an area for further investigation in the future. It appears that they undertake an informal process of community consultation before the onset of a research project, however, there is no formal documentation about the actual procedure or results. CSIRO also undertakes market research to ascertain, for example, which type of products containing GM long-chain omega-3 oils would be more acceptable to the broader community.

## Recommendations

### CSIRO

CSIRO should review and potentially improve upon their current informal system of public engagement prior to a research project being initiated by introducing a formal TA process. This could take the form of a stepped process whereby technologies that may have social consequences can be identified and investigated (as was outlined in the TASC project). This may be facilitated by an independent TA practitioner with the view of forming an iterative arena where communication and ongoing learning can occur between science and a broad range of social groups from the onset of research through to commercialisation.

The product of the omega-3 project faces challenges that require further attention. The lack of public knowledge related to differences between long and short-chain omega-3 fatty acids is a barrier. It is still to be clarified if current or future legislation requires the oil to be labelled as a product of GM under FSANZ Standard 5.1.2. Many case study participants were willing to use the GM oil, but were insistent that it should be labelled as a GM product to enable them to make an informed choice.

### The Australian food industry

Referring to GM technology, there are still gaps in the regulatory system that need to be addressed, for example, compensation in the advent of inadvertent mixing of GM and GM-free crops. The amount of scientific monitoring of GM versus non-GM crops and foods is still a topic of debate. FSANZ could be provided with more resources to expand their current portfolio to include environmental and health monitoring or elect an independent organisation to undertake these activities.

The food industry should consider the future of food in Australia more broadly and create a whole of government food and nutrition policy using vision TA tools. This is likely to produce a shared vision for Australia that would include a thorough democratic debate from wide range of social groups that can underpin policy-making from research and development through to public health assessment. This should reduce replication of strategies and policies by different government agencies and maximise tax payers money to maximise social outcomes. The aim would be to establish a holistic approach to create sustainable long-term strategy for the future of food in Australia.

TA tools have been developed that could be used by multi-national corporations to enhance corporate social responsibility and increase public trust. TA could provide a useful framework that could address some of the issues occurring throughout the food-chain in Australia. Perhaps a system of TA accreditation could be implemented?

The type of TA, where and how it could be institutionalised in Australia and funded still have to be established. Collaboration with other countries that are currently involved in the development and implementation of TA should be encouraged.

## Closing remarks

This thesis has demonstrated that technology assessment can be useful in the Australian food industry as it provides a systematic process of identifying the social, ethical and legal issues that new food technologies may create. Establishing a technology assessment framework early in the research and development process would create an iterative and interactive arena where a broad range of social groups can influence the decision-making process about which technologies should be developed. This can help technology developers consider other alternatives or make changes to the products being developed to increase social acceptance. Identifying issues provides an opportunity to mitigate any adverse social consequences that could be experienced by a particular social group. This may require changes to current legislation, structure and/or the portfolio of government agencies. A TA process would enhance democratic principles especially where public funds are being used for research into a particular area. As reported by the TASC team, a formal TA agency in Australia similar to those in Europe could improve technology policy and governance. This would improve upon the current fragmented, uncoordinated and variable quality TA-like activities that have been conducted in various Australian institutions. The results of this research have been recently published in the paper: Russell, A.W., Vanclay, F., Salisbury, J. & Aslin. H. (in press) "Technology assessment in Australia: The case for a formal agency to improve advice to policy makers", *Policy Sciences* (letter of acceptance 12 July 2010). DOI 10.1007/s11077-010-9120-4. The work by Russell et al. (2010) in the above paper has identified the quality criteria that would characterise a good TA as being systematic, broad, inclusive and well resourced.

TA vision assessment framework has the potential to create a shared vision for the future of food, which would facilitate communication and learning between social groups. It would also provide policy-makers with a broader information base as it would include subjective as well as objective science-based knowledge. Further work is required to ascertain the most appropriate type of TA and determine the best way to formally institutionalise it in Australia. The thesis is significant in that it is likely to be the first Australian application of technology assessment in the food industry.

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